

## **12.1. 40 CFR 122.21(r)(12) - Non-Water Quality Environmental and Other Impacts Study**

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### **12.2. INTRODUCTION**

In conjunction with 40 Code of Federal Regulations (CFR) §122 and 125, the USEPA promulgated new regulations regarding the NPDES - Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities (the Rule). The Rule establishes requirements under Section §316(b) of the CWA to ensure that location, design, construction, and capacity of CWIS reflect the best technology available for minimizing adverse environmental impacts. The purpose of this action is to reduce impingement and entrainment of fish and other aquatic organisms at CWIS used by power generation and manufacturing facilities to withdraw cooling water.

Section 122.21(r)(12) of the Rule requires the owner or operator of a facility with a CWIS that withdraws greater than 125 MGD AIF to a detailed facility-specific discussion of the changes in non-water quality environmental and other impacts attributed to each technology and operational measure considered in paragraph (r)(10) of the Rule, Comprehensive Technical Feasibility and Cost Evaluation Study, including both impacts increased and impacts decreased. The study that must be submitted for the facility under 40 CFR §122.21(r)(12) includes the following:

- Estimates of changes to energy consumption;
- Estimates of air pollutant emissions and of the human health and environmental impacts associated with such emissions;
- Estimates of changes in noise;
- A discussion of impacts to safety, including documentation of the potential for plumes, icing, and availability of emergency cooling water;
- A discussion of facility reliability, including but not limited to facility availability, production of steam, impacts to production based on process unit heating or cooling, and reliability due to cooling water availability;
- Significant changes in consumption of water; and
- A discussion of all reasonable attempts to mitigate each of these factors.

Ameren's LEC is a coal-fired facility and is therefore, not subject to requirements relevant to nuclear facilities.

The following sections present the information required pursuant to 40 CFR §122.21(r)(12) for Ameren's LEC.

### **12.3. BACKGROUND**

The LEC is located adjacent to the Missouri River near Labadie, Missouri which is approximately 35 miles west of St. Louis, in Franklin County (Figure 12.1). LEC is located on the south bank of the Missouri River at river mile 57.5.

The LEC operates year-round as a baseload facility. The plant consists of four generating units with a net capability of 2,580 MW. Over the six-year period of 2008-2013, the average capacity factor for the four units combined was 81.9%, with capacity factors of the individual units ranging from 80.7% to 82.7%. Operation of the plant with respect to Section §316(b) is subject to the conditions of NPDES Permit No. MO-0004812 issued by the MDNR.

The LEC currently utilizes a once-through cooling water system to condense turbine exhaust steam and to provide plant auxiliary cooling water. Cooling water for all four units is withdrawn from the Missouri River via a single shoreline CWIS located on the right descending bank of the river. The CWIS currently has eight intake bays, two for each unit.

Water level elevations at the intakes typically range from 450 feet at design low water level to 484 feet at high water but have reached a maximum level of 490 feet and a minimum low level of 446 feet. The mean water level is 455 feet.

The LEC's circulating water pumps are vertical pumps installed in wet pit intake bays. The flow rate provided by the constant speed pumps is dependent on river level. An increase in river elevation reduces pumping head required and increases the pump flow rate. The total intake structure is designed for a flow rate of 2,240 cfs at the normal river elevation of 455.0 ft. This corresponds to approximately 1,005,400 gpm or 125,750 gpm per pump. At the design low water level of 450 feet the total design flow is 2,104 cfs. This corresponds to 944,300 gpm or 118,000 gpm per pump.

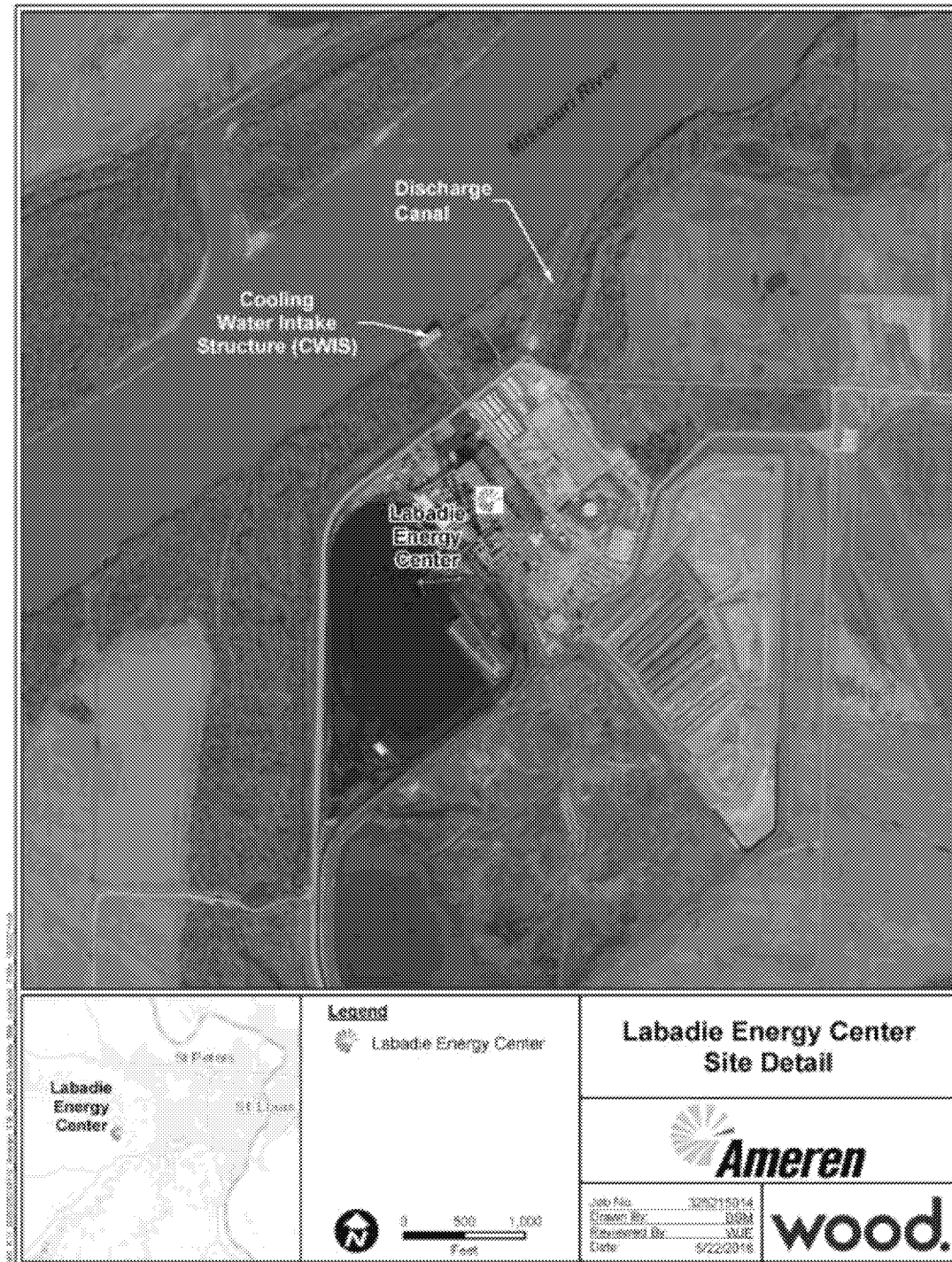


Figure 12.1. Location of Ameren's Labadie Energy Center on the Missouri River

## **12.4. TECHNOLOGIES AND OPERATIONAL MEASURES CONSIDERED IN THE (R)(10) ANALYSIS**

40 CFR §122.21(r)(10) requires the owner or operator of an existing facility that withdraws greater than 125 MGD AIF must develop for submission a Comprehensive Technical Feasibility and Cost Evaluation Study that assesses the technical feasibility, practicality and incremental costs of candidate entrainment control technologies. This study, referred to as the (r)(10) study, was conducted for the LEC and evaluated a range of candidate entrainment control technologies (including an evaluation of technical feasibility of closed-cycle cooling and fine mesh screens with a mesh size of 2 millimeters [mm] or smaller), reuse of water, and potential alternate sources of cooling water (groundwater). The (r)(10) study concluded that the cooling water technologies feasible and practical for consideration at the LEC are:

- Mechanical Draft Cooling Towers, and
- Fine Mesh Modified Traveling Screens

These feasible and practical technologies retained for consideration in the (r)(11) and (r)(12) reports are described in the following sections.

### **12.4.1 Mechanical Draft Cooling Towers**

Wet cooling towers reduce the temperature of a water stream by extracting heat from the water and emitting it to the atmosphere via evaporation of a small portion of the water stream. Mechanical draft towers use fans to draw air through falling circulated water. The water falls over fill surfaces, which helps increase the contact time between the water and the air, maximizing heat transfer between the two. A portion of the water evaporates, which cools the remainder of the water.

Closed cycle cooling technologies, including mechanical draft cooling towers, significantly reduce entrainment losses because source waterbody withdrawal rates are significantly reduced or eliminated. The proposed cooling tower system at the LEC would be a closed loop, with the necessary make-up water provided via groundwater collector wells, eliminating the need for cooling water withdrawal from the Missouri River.

The preliminary design for a mechanical draft cooling tower retrofit at the LEC would include the installation of four new cooling towers, with 20 cells per tower. Multiple-cell towers can be linear, square, or round depending upon the shape of the individual cells and whether the air inlets are located on the sides or bottoms of the cells. The most efficient and common designs are long rectangular configurations, as utilized in the proposed design at the LEC (Figure 12.2).



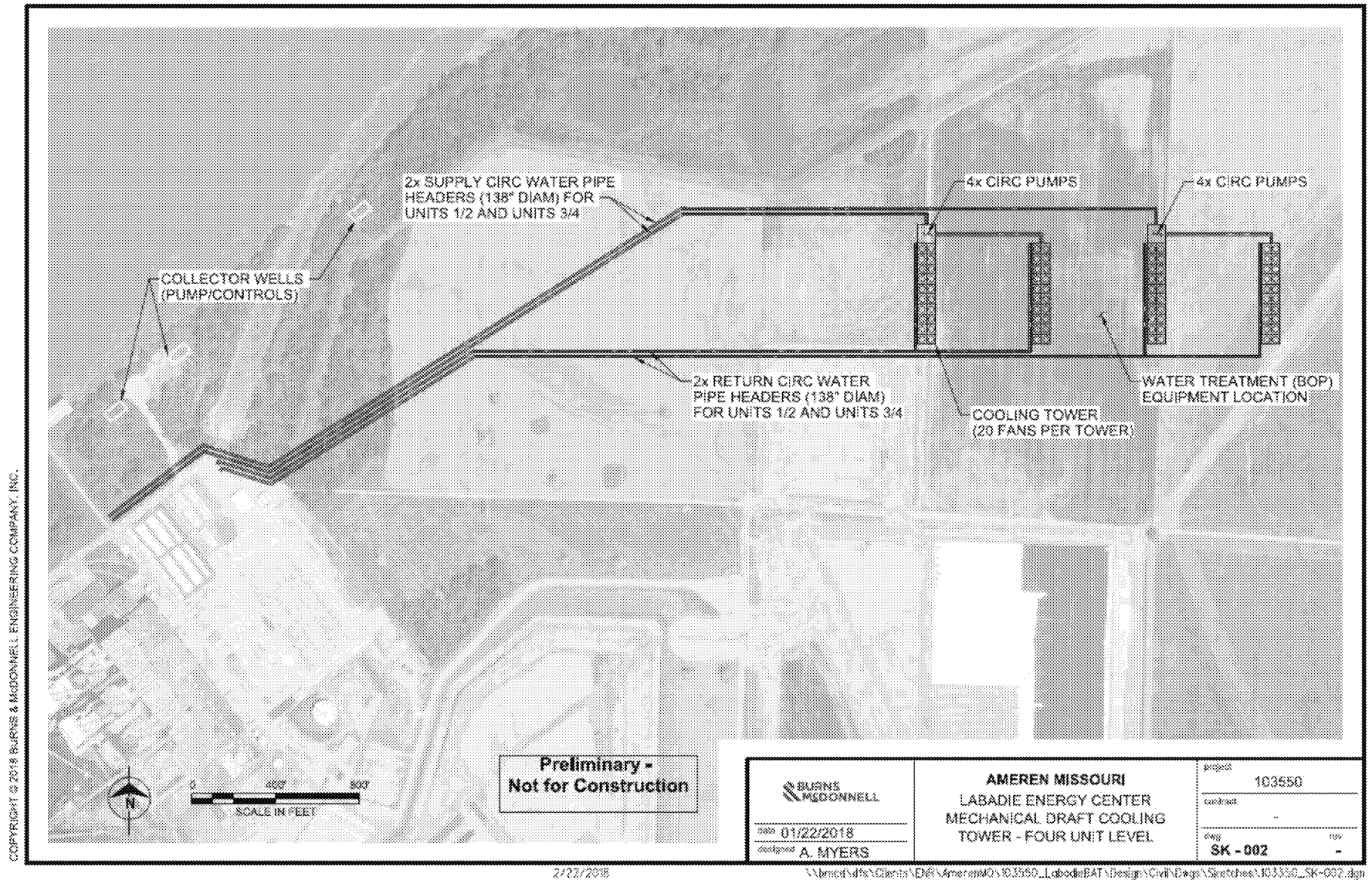


Figure 12.2. Proposed Mechanical Draft Cooling Tower Configuration  
(Source: Burns and McDonnell, 2018)

While other cooling tower arrangements were evaluated and considered to be feasible, they were more costly. Therefore, because mechanical draft cooling towers were both lower cost and feasible and practical, it was retained as the technology for use in (r)(11) and (12).

#### **12.4.2 Fine Mesh Modified Traveling Screens**

Fine mesh (equal to 2.0 mm or smaller) screen technologies provide entrainment protection through exclusion and survivability of aquatic organisms. Exclusion of an organism is based on the screen mesh dimensions and the size of the organism. Survivability is based on the force with which the organisms are pushed against the screen (through-screen velocity) and the handling characteristics of the system that removes the organism from the screen and returns it to the source waterbody.

The preferred alternatives for installation of fine mesh at the LEC allow for the replacement of the current 3/8-inch mesh traveling water screens with 2.0 mm or smaller screen mesh while maintaining both the current cooling water flow and a through-screen velocity equal to or less than the current calculated velocity. Two modifications to the existing intake structure were determined to meet these criteria and were retained for further consideration:

- 2.0 mm Dual-Flow Fine Mesh Modified Traveling Water Screen Conversion
- 0.5 mm Thru-Flow Fine Mesh Modified Traveling Water Screen in an Expanded Cooling Water Intake Structure

As both fine mesh traveling screen modifications involve the continued use of the existing CWIS and related infrastructure in accordance with §125.94(c)(5), many of the non-water quality impacts associated with these modifications are indistinguishable. Therefore, in the (r)(12) analysis, they are generally referred to collectively under the broader designation of Fine Mesh Modified Traveling Screens. In instances where non-water quality impacts between the two screen modification options differ, they are broken out and assessed separately.

##### **12.4.2.1 2.0 mm Dual-Flow Fine Mesh Screen Conversion**

Analysis of available screen alternatives indicates that it is likely feasible to install dual flow 2.0 mm x 2.0 mm fine mesh conversion screens in the existing CWIS, shown in Figure 12.3, and increase screen surface area such that enough cooling water flow could be provided at the existing through-screen velocity to operate the plant as it currently operates. The existing CWIS would need to be modified to accommodate the dual-flow screens. At a minimum, the floor slab upstream from the existing screen will have to be partially demolished. Other modifications may also be required or beneficial. For instance, it would be beneficial to locate the screen as far downstream from the stop gates as possible, which may require modification of concrete support beams within the CWIS framing structure.

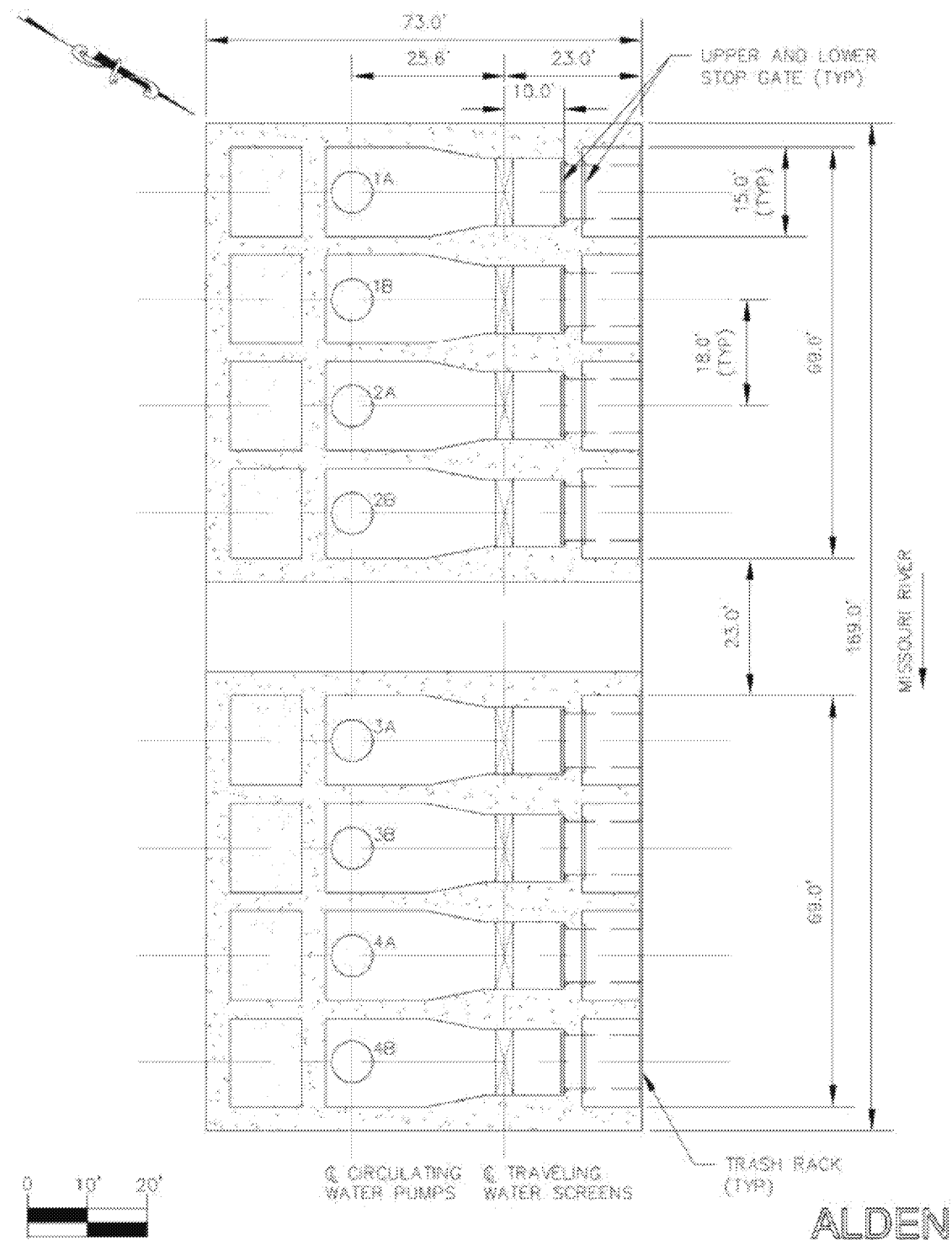


Figure 12.3. Existing CWIS Plan Detail  
(Source: Alden 2005)

#### ***12.4.2.2 0.5 mm Fine Mesh Screen in an Expanded Cooling Water Intake Structure***

The mesh size preferred to maximize exclusion is 0.5 mm x 0.5 mm fine mesh. Several alternative arrangements for the expansion of the CWIS to accommodate 0.5 mm fine mesh were conceptualized. For this level of hypothetical analysis, a single alternative was selected for further development, in which 14 new screen bays would be constructed to accommodate the flow and velocity requirements (Figure 12.4). The proposed design entails the construction of new intake bays with trash racks, gates and traveling water screens flanking the existing CWIS. Forebays would be constructed to channel water into the existing CWIS bays. The trash racks and traveling water screens would be removed from the existing bays. The existing pumps and condenser piping system would remain and continue to operate. The total length of the new intake would be approximately 420 feet long. A fish handling and return system would be installed for all bays and a warm water, recirculating, piping system would be installed to minimize the potential for icing.

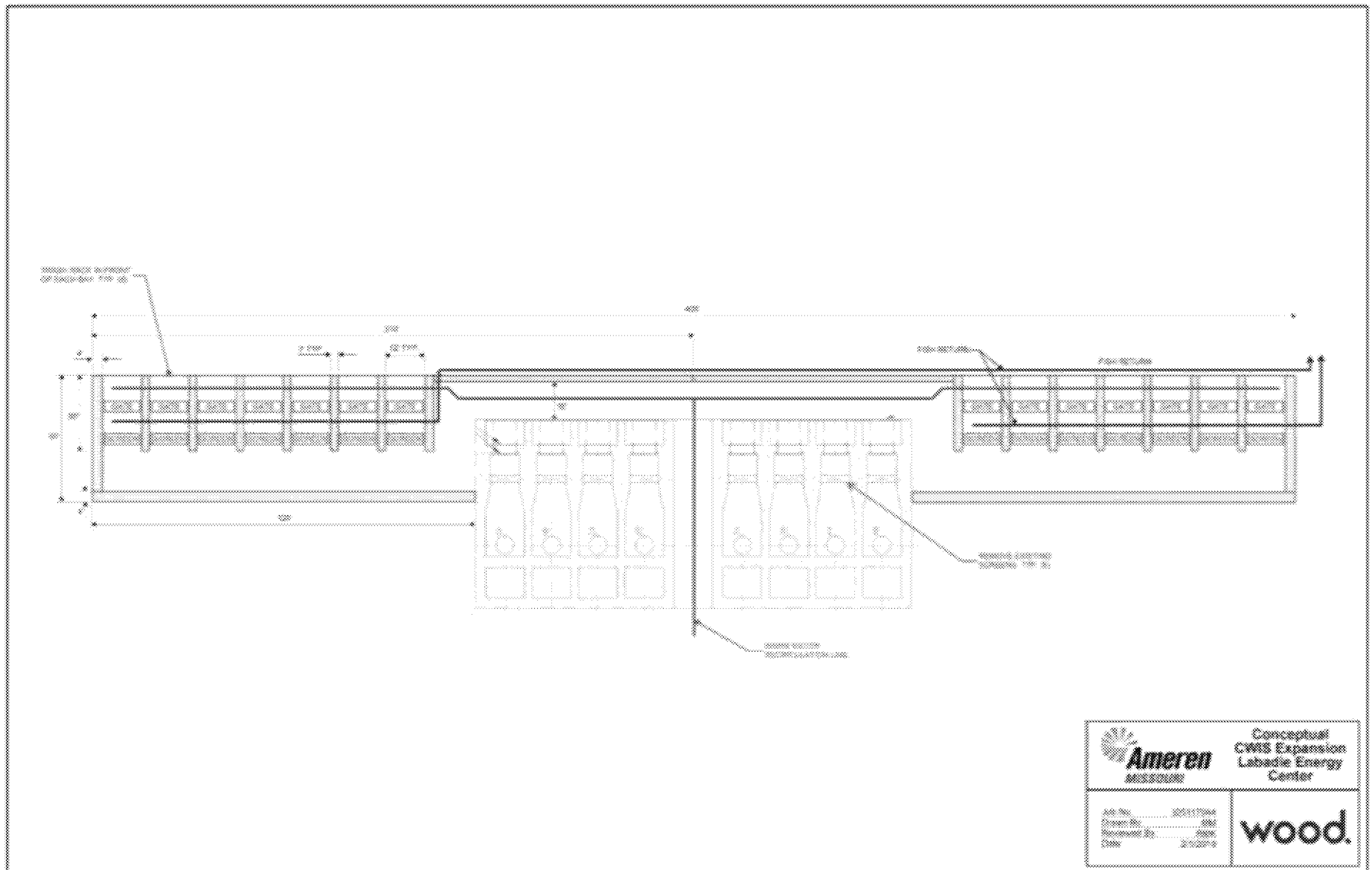


Figure 12.4. Proposed CWIS Expansion to Accommodate 0.5 mm Fine Mesh Screens

## 12.5. ANALYSIS OF NON-WATER QUALITY IMPACTS

40 CFR §122.21(r)(12) requires the owner or operator of an existing facility that withdraws greater than 125 MGD AIF to develop a detailed facility specific discussion of the changes in non-water quality environmental and other impacts attributed to each technology and operational measure considered in the (r)(10) study, including both impacts increased and impacts decreased. This Rule addresses six types of non-water quality impacts and mitigation. Required elements of the non-water quality impacts analysis include the following:

- ▶ energy consumption,
- ▶ air pollutant emissions,
- ▶ noise,
- ▶ safety concerns,
- ▶ facility reliability, and
- ▶ consumptive water use.

The following analysis provides the detailed description of the non-water quality impacts and mitigation measures considered for each of the cooling water technologies determined optimal for the LEC in the (r)(10) study.

### 12.5.1 Energy Consumption

The following section provides an estimate of changes to energy consumption associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(i):

*Estimates of changes to energy consumption, including but not limited to auxiliary power consumption and turbine backpressure energy penalty*

#### 12.5.1.1 Mechanical Draft Cooling Towers

The preliminary design for a mechanical draft cooling tower retrofit at the LEC would include the installation of four new cooling towers, with 20 cells per tower. Retrofitting to closed-cycle cooling would result in a net loss in plant output due to both the increased auxiliary power consumption from the additional electrical demand to operate the cooling towers, and the decrease in power output due to turbine efficiency loss.

Auxiliary loads would increase with the addition of cooling tower fans, larger pumps for circulating the cooling water, and various balance of plant (BOP) auxiliary equipment including raw water makeup

pumps, chemical feed pumps, water treatment equipment, and blowdown pumps. Power requirements for the circulating water pumps and fans to operate the cooling towers were determined to be:

- ▶ Eight new circulating water pumps (2 per cooling tower) at approximately 4,200 hp each.
- ▶ Eighty cooling tower fans (20 per cooling tower) at approximately 250 hp each.

The auxiliary loads for this equipment were provided by Burns and McDonnell (2019). The calculations of net auxiliary load also take into account the reduction in auxiliary load due to the decommissioning of some existing equipment that would no longer be operating (i.e. existing intake pumps). Table 12.1 provides a breakdown of the estimated net auxiliary load increase for a four-unit mechanical draft cooling tower retrofit during average summer conditions (28.9 MW) and average winter conditions (23.0 MW).

**Table 12.1. Estimated Auxiliary Load for Four-Unit Mechanical Draft Cooling Tower (MW)**

Equipment	Average Summer Condition	Average Winter Condition
New Cooling Tower Fans	14.9	9.0
New Circulating Water Pumps	25.0	25.0
Other New BOP Auxiliary Equipment	1.4	1.4
<b>Total New Auxiliary Load</b>	<b>41.3</b>	<b>35.4</b>
Existing Auxiliary Loads to be Removed	12.4	12.4
<b>Net Additional Auxiliary Load</b>	<b>28.9</b>	<b>23.0</b>

Source: Burns and McDonnell, 2019

Turbine efficiency loss is the sum of loss output among all the steam turbines due to increased circulating water temperatures. Typically, especially during warmer summer conditions, cooling towers do not cool the circulating water to the same temperature as surface water used in once-through cooling. As a result, the steam is not cooled as effectively, leading to a higher steam turbine backpressure and a loss of generating efficiency. According to specifications provided by Burns and McDonnell, the turbine efficiency loss for a four-unit mechanical draft cooling tower retrofit at the LEC is estimated to be approximately 9.9 MW during average summer conditions (Burns and McDonnell, 2019). During colder, winter conditions, there is little to no generation inefficiency. The total net plant output loss is the sum of the net auxiliary load and the turbine efficiency loss. The total net plant output

loss, also referred to as the energy penalty, is estimated to be 38.8 MW during average summer conditions and 23.0 MW during average winter conditions (Table 12.2).

**Table 12.2. Energy Penalty for Four-Unit Mechanical Draft Cooling Tower (MW)**

	Average Summer Condition	Average Winter Condition
Net Additional Auxiliary Load	28.9	23.0
Turbine Efficiency Loss	9.9	0
<b>Total Net Plant Output Loss (Energy Penalty)</b>	<b>38.8</b>	<b>23.0</b>

Source: Burns and McDonnell, 2019

#### **12.5.1.2 Fine Mesh Modified Traveling Screens**

The utilization of fine mesh modified traveling screens would have no impact on steam turbine efficiency, so changes to total plant output would be limited to additional auxiliary loads. New auxiliary loads for the two screen modification options are described below.

##### **12.5.1.2.1 2.0 mm Dual-Flow Fine Mesh Screen Conversion**

The power requirements for the 2.0 mm dual-flow fine mesh screens are expected to be similar to the power requirements of the anticipated future baseline operating condition of impingement compliant modified traveling water screens that would be continuously rotating and washing. The existing pumps and condenser piping system would remain and continue to operate. Therefore, there would be no appreciable changes to auxiliary load or energy consumption under this alternative.

##### **12.5.1.2.2 0.5 mm Fine Mesh Screen in an Expanded Cooling Water Intake Structure**

The use of 0.5 mm fine mesh screens in an expanded CWIS would require an additional auxiliary load for new screen drives and spray pumps. Power requirements for the additional equipment were determined to be:

- ▶ 14 new screen drives at approximately 15 hp each.
- ▶ Five spray pumps at approximately 200 hp each.

This results in an additional auxiliary load of 157 kilowatts (kW) for the new screen drives and 746 kW for the new spray pumps, when operating at full capacity. Therefore, the maximum additional auxiliary load under this alternative is estimated to be 903 kW or approximately 0.9 MW. The existing pumps and condenser piping system, which have an auxiliary load of 12.4 MW, would remain and continue to operate, resulting in a total auxiliary load loss of 13.3 MW.



## **12.5.2 Air Pollutant Emissions and Human Health and Environmental Impacts**

The following section provides an estimate of air pollutant emissions and associated impacts resulting from the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(ii):

*Estimates of air pollutant emissions and of the human health and environmental impacts associated with such emissions*

Air quality is protected by the Clean Air Act (CAA) and air quality standards established by the USEPA. As required by the CAA, the USEPA has established National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. These are carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter (PM), particulate matter less than 10 microns in diameter (PM<sub>10</sub>), particulate matter less than 2.5 microns in diameter (PM<sub>2.5</sub>), and sulfur dioxide (SO<sub>2</sub>). The LEC is not located within a designated nonattainment or maintenance area for carbon monoxide, lead, nitrogen dioxide, PM<sub>10</sub>, or SO<sub>2</sub>; however, the northeastern corner of Franklin County, where the LEC is located, has been designated as nonattainment (marginal) for 8-hour ozone. Franklin County was also designated as nonattainment (moderate) for PM<sub>2.5</sub> by the 1997 standard but was found to be in attainment in October 2018 and was therefore redesignated as a maintenance area by the USEPA (EPA, 2019).

### **12.5.2.1 Mechanical Draft Cooling Towers**

#### **12.5.2.1.1 Air Pollutant Emissions**

##### *Cooling Tower Drift Emissions*

Mechanical draft cooling towers emit particulate matter through the generation of drift emissions. During the evaporative cooling process, a small portion of liquid water droplets are carried along with the evaporated water (cooling tower drift) in the tower exhaust. Minerals and any dissolved or suspended solids in the make-up water stream can become entrained in these liquid water droplets and these constituents can be emitted as total PM, (PM<sub>10</sub>), and PM<sub>2.5</sub>. Based on the Thermal Discharge Best Available Technology Economically Achievable Analysis (BAT Analysis) for the LEC, the emissions potential for particulate matter based on a four-cooling-tower design with four cycles of concentration (COC) at LEC is estimated to be between 5 tons per year (tpy) and 20 tpy, depending on the COC design and the concentration of total dissolved solids (TDS) in the makeup water (Burns and McDonnell, 2018).

The LEC is an existing major source of air emissions permitted under the CAA, and cooling towers would be considered modifications to this existing major source. If the PM emissions from modifications to the existing major source exceed the major modification thresholds, the cooling towers would be subject to Federal permit review including Prevention of Significant Deterioration (PSD). Table 12.3 provides the maximum potential PM emissions from the proposed cooling towers and the national PSD significance levels (40 CFR § 52.21). While the estimate from the BAT Analysis

approximates a range of total PM emissions at the LEC, it has not been determined what amount of that total would be PM<sub>10</sub> and PM<sub>2.5</sub>. Therefore, the maximum potential emissions for these specific pollutants were provided under the assumption that all PM emissions were both PM<sub>10</sub> and PM<sub>2.5</sub>.

**Table 12.3. Estimated PM Emissions and PSD Significance Levels**

Pollutant	Maximum Potential Cooling Tower Emissions (tpy)	PSD Significance Levels (tpy)
PM	20	25
PM <sub>10</sub>	20	15
PM <sub>2.5</sub>	20	10

Source: Burns and McDonnell, 2018

As shown in Table 12.3, at the top end of the estimated range (20 tpy), the increase in total PM from the cooling towers would be below the PSD significance level of 25 tpy. However, under the assumption that all PM is comprised exclusively of either PM<sub>10</sub> and/or PM<sub>2.5</sub>, the emissions of these pollutants exceed the significance levels of 15 tpy and 10 tpy, respectively. Under this scenario, a PSD major modification permit would be required. However, this assumption is highly conservative and if this technology is selected, a more detailed evaluation of PM<sub>10</sub> and PM<sub>2.5</sub> emissions would be needed to determine if a PSD major modification permit would be required.

#### *Emissions Associated with Replacement Energy Generation*

A cooling tower retrofit would result in lost energy from both construction downtime and the energy penalty discussed in Section 12.5.1.1. As such, replacement energy would have to be made up by the LEC and/or the surrounding generating facilities to meet the regional transmission organization requirements. Assuming that such replacement energy is provided by fossil fuel generation facilities, this would require that these facilities burn additional fuel, thereby emitting additional carbon dioxide (CO<sub>2</sub>), SO<sub>2</sub>, nitrogen oxides (NO<sub>x</sub>), and PM.

LEC is owned and operated by Ameren Missouri, a regulated, investor-owned public utility that participates in the MISO regional transmission organization. A social cost study was conducted by Veritas Economic Consulting to determine differences in fuel consumption and associated costs and emissions for various entrainment reduction technologies at the LEC (Appendix 10E). To estimate the power system effects from capacity losses for the LEC and within the regional transmission organization, conditions were specified and input into the Ameren Missouri module of a 316(b)-focused power system model called the Environmental Policy Simulation Model (EPSM). The process was implemented by carrying out the following steps within EPSM's power system module:

1. Estimate the hourly energy penalty
2. Specify total hourly load

3. Operate model consistent with load and unit characteristics
4. Create scenarios representing LEC's conversion and ongoing operations
5. Run EPSM model to identify counterfactual dispatch
6. Calculate differences in fuel consumption, emissions, and costs

The calculated changes in power generation due to the operation of four mechanical draft cooling towers at LEC would lead to changes in fuel consumption and CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and PM emissions in the Ameren Missouri Region. As each generating unit would be converted to closed-cycle cooling individually, over the course of approximately four years, the additional fuel consumption and associated air emissions would increase throughout the conversion years as additional units are converted. Post conversion operations, ongoing after Conversion Year 4, reflect the increased emissions due to replacement energy generation needed to account for the energy penalty associated with closed-cycle cooling for all four units.

Increases in emissions during the first conversion year are estimated to amount to 47,510 tons of CO<sub>2</sub>, 230 tons of SO<sub>2</sub>, 30 tons of NO<sub>x</sub>, and 1,990 tons of PM (Table 12.4). Emissions would increase incrementally over the following conversion years until all units have been converted to a closed-cycle cooling tower system. Following Conversion Year 4, and continuing in ongoing years, increases in emissions would amount to approximately 221,600 tons of CO<sub>2</sub>, 490 tons of SO<sub>2</sub>, 124 tons of NO<sub>x</sub>, and 9,290 tons of PM annually.

**Table 12.4. Incremental Indirect Emissions Due to the Reduced Generating Capacity from Closed-Cycle Cooling**

Pollutant	Tons				Ongoing Year
	Conversion Year 1	Conversion Year 2	Conversion Year 3	Conversion Year 4	
CO <sub>2</sub>	47,510	98,790	154,000	208,300	221,600
SO <sub>2</sub>	230	330	430	480	490
NO <sub>x</sub>	30	80	110	119	124
PM	1,990	4,140	6,460	8,730	9,290

Source: Veritas, 2019 (Appendix 10E)

#### **12.5.2.1.2 Human Health Impacts**

According to the EPA, the size of PM emissions is directly linked to their potential for causing human health impacts. PM<sub>10</sub> poses the greatest problems, because particles smaller than 10 micrometers can, once inhaled, enter the lungs and cause serious health effects. Exposure to such particles can affect both the respiratory and circulatory systems. Numerous scientific studies have linked PM pollution exposure to a variety of problems, including:

- premature death in people with heart or lung disease;
- nonfatal heart attacks;
- irregular heartbeat;
- aggravated asthma;
- decreased lung function; and
- increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

People with pulmonary and respiratory diseases, children, and older adults are the most likely to be affected by PM pollution exposure (EPA, 2018). While the PM emissions from a cooling tower, such as inorganic salts and organic material, likely result in lesser adverse health effects than do combustion-derived particles (i.e. smoke), research has not been able to precisely quantify the contributions of different PM components to human health effects from PM exposure (World Health Organization 2006). Therefore, there is a possibility that increased PM emissions from cooling tower drift can result in impacts to human health.

In 2011, the Electric Power Research Institute (EPRI) conducted a technical study entitled *Net Environmental and Social Effects of Retrofitting Power Plants with Once-Through Cooling to Closed-Cycle Cooling* (Closed-Cycle Cooling Effects Study) (EPRI, 2011a). In the study, potential upper bounds for possible human health impacts associated with increases in PM emissions from cooling tower retrofits were estimated through human health risk assessment. The risk assessment methodology used to evaluate human health impacts was based on the document entitled *Particulate Matter Health Risk Assessment for Selected Urban Areas* (EPA, 2005). This USEPA document describes a series of concentration-response functions developed through evaluation of epidemiological evidence to assess the relationship of PM concentration and health effects responses. The generalized USEPA concentration-response function was used to estimate the increased incidence of the following endpoints that may occur, over and above possible current baseline effects associated with ambient PM:

- Mortality due to long-term exposure to an increased concentration of PM<sub>2.5</sub>; and
- Hospital admissions for treatment of morbidity effects such as heart disease, bronchitis, emphysema, and pneumonia due to exposure to increased concentrations of PM<sub>2.5</sub> and/or PM that measures between 10 and 2.5 microns in diameter.

EPRI research indicates the EPA's methods and their application in this closed-cycle cooling analysis results in very conservative risk estimates at the high end of the upper bound.

The EPRI study included a risk assessment for 24 power plant facilities, representing a variety of fuel types, climatic regions, waterbody types, and surrounding population density. As PM concentrations are highly dependent upon the makeup and salinity of the cooling water, the representative facilities

were grouped based on waterbody type. To account for populations exposed, they were also categorized into low, medium, and high population densities (Table 12.5).

**Table 12.5. EPRI Study Population Density Categories**

<b>Population Category</b>	<b>Density (people/square mile)<sup>1</sup></b>
Low	<100
Medium	100-1,000
High	>1,000

<sup>1</sup>Based on year 2000 population data for census tracts within which the facilities are located

Under the criteria outlined in the EPRI study, the LEC would fall into the subgroup characterized by medium population density and a water source consisting of a large river, reservoir, or lake. Although the cooling tower design proposes to use make-up water provided via groundwater collector wells rather than sourcing water from the Missouri River, this category still most accurately represents LEC. TDS in groundwater would be more similar to those in rivers, reservoirs, or lakes than TDS of water bodies in subgroups with higher salinities such as oceans, estuaries, and tidal rivers.

Four of the representative facilities individually analyzed in the risk assessment (Beta Test Plant “D”, Beta Test Plant “E”, Representative Facility “G”, and Representative Facility “J”) also belong to the medium population density and large river, reservoir, or lake water source subgroup. The estimated annual risk of increased mortality and morbidity due to cooling tower PM emissions for these four representative facilities are provided in Table 12.6. Values represent an approximation of the estimated human health risks associated with closed-cycle cooling retrofits.

**Table 12.6. Estimated Annual Risk of Increased Mortality and Morbidity due to Cooling Tower PM Emissions**

Representative Facility	Annual Mortality (# of Deaths Over Baseline) <sup>1</sup>	Annual Morbidity (# of Hospital Visits Over Baseline) <sup>1</sup>		
		Cardiovascular Disease	Chronic Obstructive Pulmonary Disease	Pneumonia
Beta Test Plant "D"	0.002	0.009	0.0006	0.002
Beta Test Plant "E"	0.01	0.1	0.007	0.02
Representative Facility "G"	0.0007	0.005	0.0001	0.0008
Representative Facility "J"	0.003	0.02	0.001	0.004

<sup>1</sup>Values are fractional probabilities of occurrence whereby:

- 0.1= 1 occurrence in 10 years
- 0.01= 1 occurrence in 100 years
- 0.001= 1 occurrence in 1,000 years
- 0.0001= 1 occurrence in 10,000 years

The estimates for all representative facilities in the EPRI study were calculated assuming that mechanical draft evaporative cooling towers are equipped with drift eliminators to limit the drift rate to 0.0005 percent of the circulating water flow rate. Efficient drift eliminators are commonly required for permitting and have also been included in the cooling tower design at the LEC. Therefore, the estimated annual risk of increased mortality due to cooling tower PM emissions from the LEC, based on the risk assessment of similar facilities presented in Table 12.6, is likely in the vicinity of 0.0007 to 0.01 deaths over baseline per year, or conservatively, one death over baseline every 100 years. Cardiovascular disease is the condition with the highest annual morbidity, with the high end approaching 0.1 hospital visit over baseline per year, or one visit every 10 years. The high-end estimates for annual morbidity of Chronic Obstructive Pulmonary Disease, which includes lung diseases like emphysema, chronic bronchitis and asthma, is 0.007 hospital visits over baseline (1 additional visit every 142 years), and for pneumonia is 0.02 hospital visits over baseline (1 additional visit every 50 years).

As discussed in Section 12.5.2.1.1, air pollutants (CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub> and additional PM) will be emitted as a result of the replacement energy generation associated with the utilization of cooling towers. Similar to cooling tower PM emissions, these additional air pollutants can cause an increased likelihood of respiratory problems, including inflammation of the lungs, bronchitis, and complications with asthma. However, as the impacts of these air pollutants are not reliably quantifiable and may occur elsewhere in the region, they are not accounted for above. Therefore, there is a potential for minor additional health impacts to occur regionally due to replacement energy generation emissions.

### **12.5.2.1.3 Environmental Impacts**

Increased particulate matter emissions from cooling tower drift may also result in impacts to the environment. PM can be carried over significant distances by wind and then settle on ground or in water. Depending on the chemical composition, the effects of this settling may include:

- Making freshwater bodies acidic;
- Changing the nutrient balance in large river basins;
- Depleting the nutrients in soil;
- Damaging sensitive forests and farm crops;
- Affecting the diversity of ecosystems; and
- Contributing to acid rain effects (EPA, 2018).

In lieu of site-specific detailed modeling, the direction that the PM would settle at the LEC was qualitatively evaluated using wind rose data collected between 2012 and 2019 from the closest meteorological tower at the Washington Airport, located approximately 10 miles east of the proposed location of the cooling towers. Based on this data, PM would typically settle northwest and southeast of the cooling towers, potentially impacting cultivated crops that surround the site, as well as the shoreline vegetation and Missouri River to the northwest.

The amount of salt and mineral drift from cooling towers at the LEC would be minor compared to those of coastal facilities due to the use of freshwater makeup water. PM emissions from cooling tower drift, modeled by EPRI in the Closed-Cycle Cooling Effects Study, were determined to be significantly greater for the higher salinity makeup water withdrawn from oceans, estuaries, and tidal rivers (i.e., average of 388.1 tpy/facility) compared to facilities withdrawing from freshwater (i.e., average of 17.1 tpy/facility) (EPRI 2011a).

Additionally, the U.S. Nuclear Regulatory Commission (NRC) found, in an analysis of 24 licensed nuclear power plants that use wet cooling towers, that the worst-case PM emissions from cooling tower drift only had a minor impact potential. The analysis found that the majority of the deposition from cooling towers occurs in relatively close proximity to the towers. Generally, deposition rates from these cooling towers were below those known to result in measurable adverse impacts on plants, and most nuclear plants showed no indication of deposition effects on agricultural crops or plant communities in the vicinity (NRC, 2013). Therefore, in consideration of the reliance of the LEC cooling towers on freshwater and the prior studies conducted by EPRI and NRC, the impact of cooling tower PM emissions from the LEC on the surrounding environment are expected to be minimal.

In addition to impacts from PM, the construction of the cooling towers would have a direct impact on the terrestrial environment within the footprint of the proposed towers. However, as the lands proposed for cooling tower development at the LEC are made up of cultivated cropland, no rare or sensitive habitats will be directly impacted. There are no National Wetlands Inventory (NWI) mapped wetlands

or surface water bodies within the proposed footprint (Figure 12.5), and while the area is located within designated critical habitat for the federally endangered Indiana bat (*Myotis sodalis*), no suitable habitat is present as there are no trees located within the proposed cooling tower footprint.

#### **12.5.2.2      *Fine Mesh Modified Traveling Screens***

##### **12.5.2.2.1      *2.0 mm Dual-Flow Fine Mesh Screen Conversion***

Modification of the CWIS to accommodate 2.0 mm dual-flow fine mesh screens would require the use of mechanized equipment to demolish portions of the floor slab, which may include the use of barge and tow operations, pile drivers, graders, dozers, dump trucks and other related equipment. As such, localized emissions are expected to result from equipment operation. However, such emissions are anticipated to be short term and minor.

As there would be no appreciable changes to auxiliary load or energy consumption associated with the use of 2.0 mm fine mesh screens, there would be no reduction in generating capacity or increased air emissions resulting from replacement energy generation. Changes in air pollutant emissions due to this technology would be negligible, and no resulting impacts to human health or the environment are anticipated.



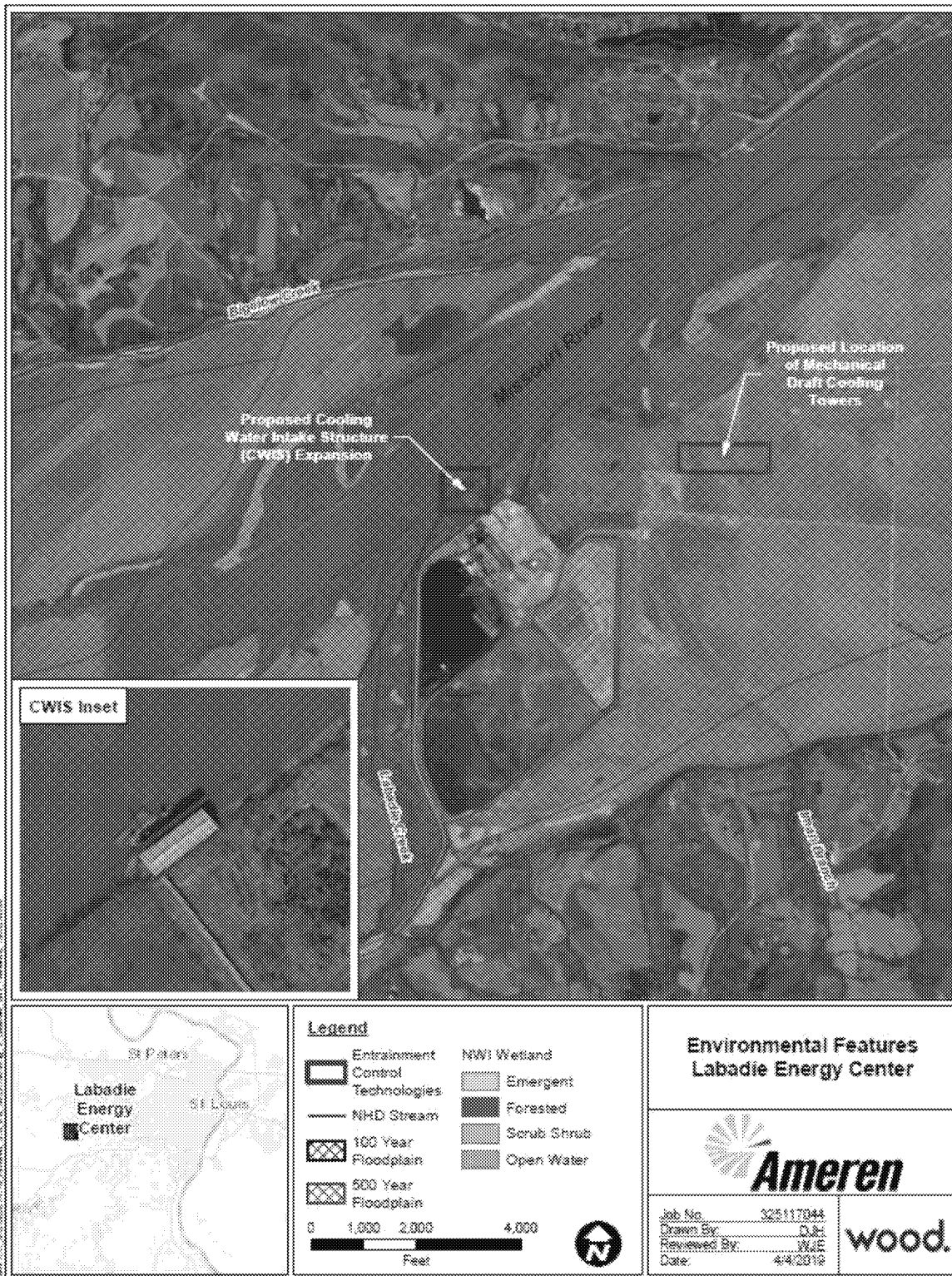


Figure 12.5. Environmental Features in the Vicinity of LEC

### 12.5.2.2.2 0.5 mm Fine Mesh Screen in an Expanded Cooling Water Intake Structure

#### *Air Pollutant Emissions*

The expansion of the CWIS to accommodate 0.5 mm fine mesh screens would require use of mechanized equipment to construct and expand the intake facility. Similar to the 2.0 mm dual-flow modification, localized emissions are expected to result from equipment operation. However, such emissions are anticipated to be short term and minor.

In addition, due to the increased auxiliary load of new screen drives and spray pumps and associated reduced generating capacity, additional air emissions would result from replacement energy generation. The social cost study (Appendix 10E) used the EPSM Ameren Missouri power system module to model changes in regional fuel consumption and CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and PM emissions resulting from the use of 0.5 mm fine mesh screens in an expanded CWIS at LEC.

Increases in emissions during the conversion year are estimated to amount to 14.64 tons of CO<sub>2</sub>, 0.03 tons of SO<sub>2</sub>, 0.01 tons of NO<sub>x</sub>, and 0.61 tons of PM (Table 12.7). A typical year following the conversion is estimated to have increases of 19.67 tons of CO<sub>2</sub>, 0.04 tons of SO<sub>2</sub>, 0.01 tons of NO<sub>x</sub>, and 0.82 tons PM.

**Table 12.7. Incremental Indirect Emissions Due to the Reduced Generating Capacity from 0.5 mm Fine Mesh Screens**

Pollutant	Tons	
	Conversion Year	Following Year
CO <sub>2</sub>	14.64	19.67
SO <sub>2</sub>	0.03	0.04
NO <sub>x</sub>	0.01	0.01
PM	0.61	0.82

Source: Veritas, 2019 (Appendix 10E)

#### *Human Health Impacts*

As previously discussed, air pollutants such as CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>x</sub>, and PM can cause an increased likelihood of respiratory problems. Although impacts from these pollutants are not readily quantifiable, due to the relatively minor increase in air emissions (orders of magnitude less than those associated with cooling towers), human health impacts associated with the utilization of 0.5 mm fine mesh screens in an expanded CWIS are anticipated to be negligible.

### *Environmental Impacts*

Environmental impacts associated with the expansion of the existing CWIS are primarily associated with the construction activities and permanent loss of habitat in the areas where expansion will occur. The current design proposes to extend the CWIS by 125 feet upstream and 125 feet downstream from the current structure boundaries. It will also extend approximately 17 feet further into the river. This will result in the conversion of shoreline habitats and associated wetland and riparian zones along edge of the Missouri River. An NWI mapped freshwater forested/shrub wetland is located within the proposed expansion area to the southwest of the existing CWIS (Figure 12.5). In the event this technology is selected, further evaluation would be required to determine the extent of temporary and permanent impacts to wetland and shoreline habitats. This expansion would also entail extensive environmental reviews and permitting in conjunction with Sections 401/402/404 of the CWA, Section 10 of the Rivers and Harbors Act, Section 106 of the National Historic Preservation Act, and Section 7 of the ESA.

### **12.5.3 Noise**

The following section provides an estimate of changes in noise associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at LEC, in accordance with §122.21(r)(12)(iii):

#### *Estimates of changes in noise*

Noise is unwanted or unwelcome sound usually caused by human activity and added to the natural acoustic setting of a locale. It is further defined as sound that disrupts normal activities or that diminishes the quality of the environment. Community response to noise is dependent on the intensity of the sound source, its duration, the proximity of noise-sensitive land uses, and the time of day the noise occurs (i.e., higher sensitivities would be expected during the quieter overnight periods).

Sound is measured in logarithmic units called decibels (dB). Given that the human ear cannot perceive all pitches or frequencies of sound, noise measurements are typically weighted to correspond to the limits of human hearing. This adjusted unit of measure is known as the A-weighted decibel (dBA) which filters out sound in frequencies above and below human hearing. A noise level change of 3 dBA or less is barely perceptible to average human hearing. However, a 5 dBA change in noise level is clearly noticeable. The noise level associated with a 10 dBA change is perceived as being twice as loud; whereas the noise level associated with a 20 dBA change is considered to be four times as loud and would therefore represent a “dramatic change” in loudness.

To account for sound fluctuations, environmental noise is commonly described in terms of the equivalent sound level. The equivalent sound level is the constant noise level that conveys the same noise energy as the actual varying instantaneous sounds over a given period. Fluctuating levels of continuous, background, and/or intermittent noise heard over a specific period are averaged as if they had been a steady sound. The day-night sound level ( $L_{dn}$ ), expressed in dBA, is the 24-hour average noise level with a 10-dBA correction penalty for the hours between 10 p.m. and 7 a.m. to account for the increased sensitivity of people to noises that occur at night. Typical background day-night noise levels for rural areas is anticipated to range between an  $L_{dn}$  of 35 and 50 dB, whereas higher-density

residential and urban areas background noise levels range from 43 dB to 72 dB (EPA, 1974). Background noise levels greater than 65 dBA can interfere with normal conversation, watching television, using a telephone, listening to the radio, and sleeping. Common indoor and outdoor noise levels are listed in Table 12.8.

**Table 12.8. Common Indoor and Outdoor Noise Levels**

Common Outdoor Noises	Sound Pressure Levels (dB)	Common Indoor Noises
Jet Flyover at 300 meters (984.3 feet)	110	Rock Band at 5 meters (16.4 feet)
Gas Lawn Mower at 1 meter (3.3 feet)	100	Inside Subway Train (New York)
Diesel Truck at 15 meters (49.2 feet)	90	Food Blender at 1 meter (3.3 feet)
Gas Lawn Mower at 30 meters (98.4 feet)	80	Garbage Disposal at 1 meter (3.3 feet)
Commercial Area	70	Shouting at 1 meter (3.3 feet)
Quiet Urban Daytime	60	Vacuum Cleaner at 3 meters (9.8 feet)
Quiet Urban Nighttime	50	Normal Speech at 1 meter (3.3 feet)
Quiet Suburban Nighttime	40	Large Business Office
Quiet Rural Nighttime	30	Dishwasher Next Room
	20	Small Theater, Large Conference Room
	10	Library
	0	Bedroom at Night
		Concert Hall (Background)
		Broadcast and Recording Studio
		Threshold of Hearing

Source: Arizona DOT 2008

Neither the state of Missouri nor Franklin County have passed ordinances to regulate nuisance noise. The EPA 1974 guidelines recommend that  $L_{dn}$  not exceed 55 dBA for outdoor residential areas. The U.S. Department of Housing and Urban Development (HUD) considers an  $L_{dn}$  of 65 dBA or less to be compatible with residential areas (HUD 1985).

The LEC is located along the south bank of the Missouri River in a rural area. Current ambient noise levels at the LEC are typical of an operating industrial plant. Other noise generating sources in the vicinity of the plant include periodic barge operations or boats on the river and noise from nearby

residential traffic and local farm operations. Overall, the surrounding area is rural with very low density residential development and farms. Klondike Park and sections of the Katy Trail are located directly across the river from LEC. These recreational facilities, as well as several single-family residences in the vicinity, are considered sensitive noise receptors that could be negatively impacted by substantial increases in ambient noise.

### 12.5.3.1 Mechanical Draft Cooling Towers

Construction of the mechanical draft cooling towers would require use of mechanized equipment, which may include the use of pile drivers, graders, dozers, dump trucks and other related equipment. Sound levels of up to 95 dBA can be expected at a distance of 50 feet from the construction area during use of this equipment (Federal Highway Administration 2016). Based on straight line noise attenuation, it is estimated that maximum construction noise levels of 95 dBA at a distance of 50 feet from the cooling tower construction site would attenuate to 55.4 dBA at the closest portion of the Katy Trail, which also serves as the southern boundary for Klondike Park (Table 12.9). The construction noise would attenuate to 53.8 dBA at the closest residence, located approximately 5,740 feet to the southeast. The locations of the sensitive noise receptors nearest to LEC and the proposed cooling towers are shown in Figure 12.6.

**Table 12.9. Attenuation of Cooling Tower Noise at Sensitive Receptors**

Sensitive Receptor	Distance from Proposed Cooling Towers (feet)	Construction Noise Level at Receptor (dBA)	Operational Noise Level at Receptor (dBA)
Katy Trail / Boundary of Klondike Park	4,791	55.4	40.4
Klondike Park Conference Center	5,295	54.5	39.5
Closest Residence to Northwest	8,017	50.9	35.9
Closest Residence to Northeast	6,160	53.2	38.2
Closest Residence to South	6,215	53.1	38.1
Closest Residence to Southeast	5,740	53.8	38.8

During operation, mechanical draft cooling towers primarily generate noise from fans and fan drives, as well as falling water. According to industry supplier SPX Corporation, for conventional mechanical draft cooling towers, sound levels of approximately 60 dBA are expected at a distance of 500 feet (as

cited in Tetra Tech, 2010a). Based on straight line noise attenuation, it is estimated that noise levels from the cooling towers would attenuate to 38.8 dBA at the nearest residence (Table 12.9).

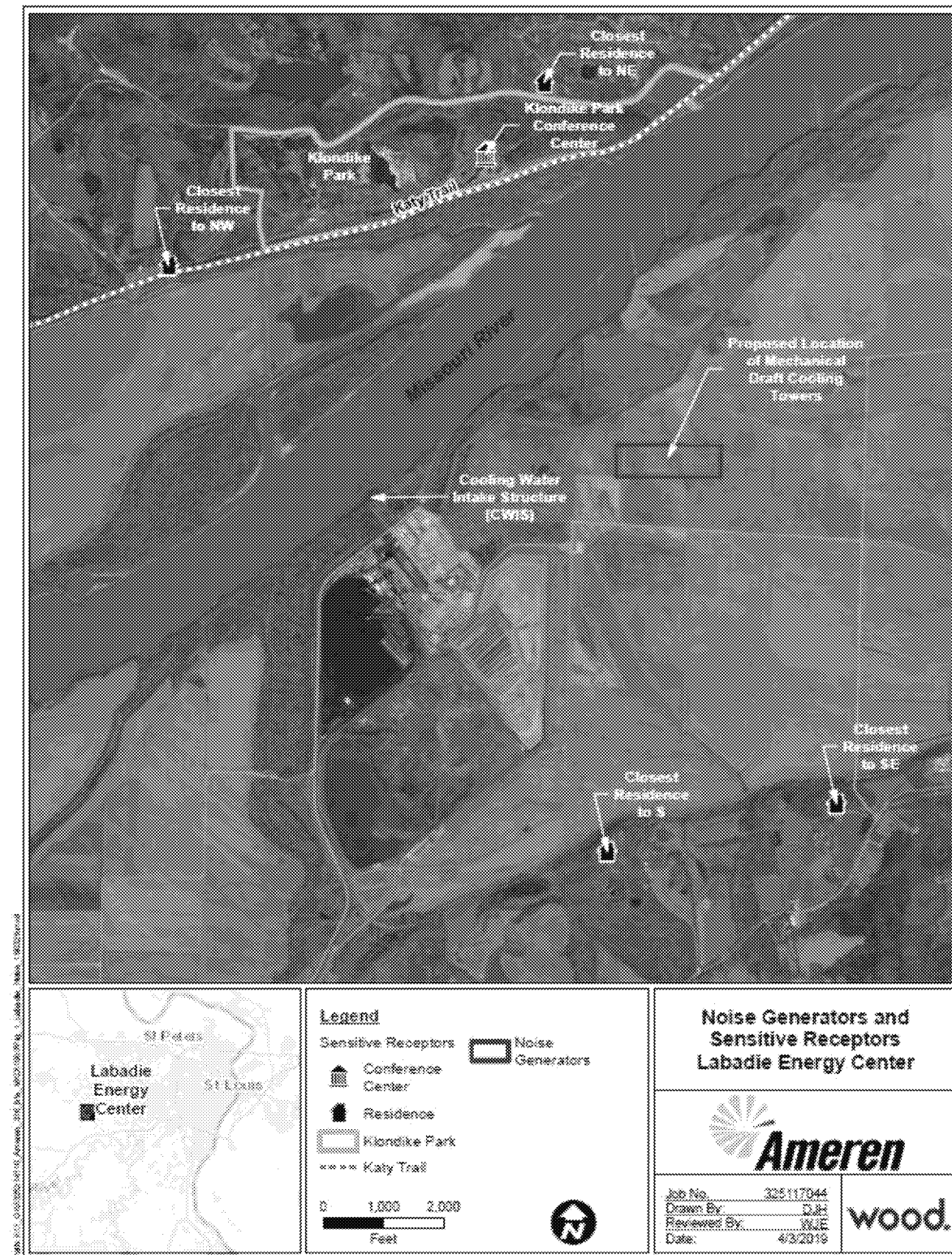


Figure 12.6. Sensitive Noise Receptors in the Vicinity of LEC

Similarly, cooling tower noise would attenuate to 40.3 dBA at the Katy Trail, which also serves as the southern border of Klondike Park, and 39.5 dBA at the Klondike Park Conference Center.

The construction noise level at the closest portion of the Katy Trail and Klondike Park boundary is slightly higher than the EPA  $L_{dn}$  guideline of 55 dBA, but lower than the HUD  $L_{dn}$  guideline of 65 dBA. Additionally, the construction noise would be intermittent and limited to the approximate 4-year duration of construction, during normal working hours. The noise levels associated with continuous cooling tower operation are below both the EPA  $L_{dn}$  guideline of 55 dBA and the HUD  $L_{dn}$  guideline of 65 dBA at all sensitive receptors.

With the absence of regulatory noise limits and the significant distance between the proposed cooling towers and the closest sensitive receptors, noise impacts from a cooling tower retrofit at LEC on the surrounding community would be minor. Nuisance noise from the cooling towers would be limited to areas within the LEC property boundary; furthermore, they would be unlikely to add a significant level of noise to an already noisy industrial site. All sensitive receptors are at enough distance that cooling tower noise would attenuate to levels below USEPA guidelines and consistent with background day-night noise levels for rural areas.

#### **12.5.3.2      *Fine Mesh Modified Traveling Screens***

Modification of the existing CWIS to accommodate fine mesh screens would require use of mechanized equipment, which may include the use of barge and tow operations, pile drivers, graders, dozers, dump trucks and other related equipment. Sound levels of up to 95 dBA can be expected at a distance of 50 feet from the construction area during use of this equipment (Federal Highway Administration 2016). Based on straight line noise attenuation, it is estimated that maximum construction noise levels of 95 dBA at a distance of 50 feet from the CWIS construction site would attenuate to 56.2 dBA at the closest portion of the Katy Trail, which also serves as the southern boundary for Klondike Park (Table 12.10). The construction noise would attenuate to 54.8 dBA at the closest residence to the CWIS, located approximately 5,100 feet to the northwest (Figure 12.6).

The construction noise level at the closest portion of the Katy Trail and Klondike Park boundary is slightly higher than the USEPA  $L_{dn}$  guideline of 55 dBA, but lower than the HUD  $L_{dn}$  guideline of 65 dBA. Additionally, the construction noise would be intermittent and limited to the duration of modification and/or expansion activities, during normal working hours. Construction noise levels at all other sensitive receptors, including all residences, are below both USEPA and HUD  $L_{dn}$  guidelines. Once construction activities are complete, operation of the CWIS with the fine mesh modified traveling screens would result in minor localized noise increases associated with the continuous screen rotation and increase in the number of traveling water screens but would not result in appreciable changes at the distance of any sensitive receptors.



**Table 12.10. Attenuation of Construction Noise Associated with CWIS Modification at Sensitive Receptors**

<b>Sensitive Receptor</b>	<b>Distance from Proposed Cooling Towers (ft)</b>	<b>Noise Level at Receptor (dBA)</b>
Katy Trail / Boundary of Klondike Park	4,345	56.2
Klondike Park Conference Center	5,855	53.6
Closest Residence to Northwest	5,100	54.8
Closest Residence to Northeast	7,515	51.5
Closest Residence to South	7,080	52.0
Closest Residence to Southeast	9,200	49.7

#### **12.5.4 Safety**

The following section provides a discussion of safety impacts associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(iv):

*A discussion of impacts to safety, including documentation of the potential for plumes, icing, and availability of emergency cooling water*

##### **12.5.4.1 Mechanical Draft Cooling Towers**

The primary safety concerns associated with the use of mechanical draft cooling towers are vapor plume impacts. Traditional wet cooling towers emit plumes of saturated air which can result in ground fogging and rime icing during cold conditions. These plume impacts are dependent upon weather conditions, and typically occur at ground level when the ambient humidity and moisture emitted in the cooling tower plume combine to create a relative humidity of 100 percent. Icing then occurs under these same conditions, when the ambient temperature is below 32 degrees Fahrenheit. Ground fogging creates safety hazards by reducing visibility, and if dense enough, vapor plumes can even affect radar transmissions and interfere with air traffic control. Rime ice can create hazardous working and driving conditions and can cause damage to structures such as transmission lines.

While the estimated frequency of ground fogging and icing at the LEC were not assessed using a Seasonal Annual Cooling Tower Impact model, the following qualitative analysis of the potential safety

impacts from vapor plumes is provided based on the conditions and surrounding infrastructure at the plant.

Decreased visibility and ice accumulation from vapor plumes could create hazardous working conditions at the LEC, potentially leading to increased worker accidents and injuries. The facility also receives coal shipments via the adjacent railroad southwest of the cooling towers. Icing or fogging could create safety challenges for rail delivery. Increased incidents of ground fogging and icing on State Route 94, located approximately 1.08 miles north of the proposed cooling towers, and Highway T, located approximately 1.15 miles southeast of the proposed cooling towers, could create an increase in hazardous driving conditions and vehicle accidents. Icing of high-capacity transmission lines is also a primary concern at LEC, as rime ice development on these lines would threaten plant operations.

In order to prevent frequent impacts from fogging and icing at the LEC facility and nearby transmission lines and railroad tracks, the design proposes to locate the cooling towers approximately 0.7 miles east of the plant and approximately 0.2 miles northeast of the closest transmission lines (Figure 12.7). The BAT Analysis (Burns and McDonnell, 2018) concluded that constructing the cooling towers at this location, a sufficient distance from the plant, would negate the need for plume abatement. Plume abatement is typically recommended for facilities within a 2-mile radius of an airport or within a 0.5-mile radius of major roads. Cooling tower plumes at the LEC are not anticipated to interfere with air traffic control because the closest airport, Washington Regional Airport, is greater than 5 miles from the proposed tower location. Both roads in the vicinity of the LEC are also outside the 0.5-mile buffer for major roads which accounts for distance required to disperse fog or ice forming plumes plus a generous safety margin (Tetra Tech, 2010b). Additionally, both roads have relatively low traffic volumes, with State Route 94 having an average annual daily traffic (AADT) of 1,462 vehicles, and Highway T having an AADT of 2,801 vehicles (Missouri Department of Transportation, 2016). Therefore, safety impacts due to cooling tower plumes are anticipated to be minimal.

Additionally, the utilization of mechanical draft cooling towers would require additional operation and maintenance worker hours when compared to existing conditions. This would result in an increase in the potential for worker accidents and injuries.

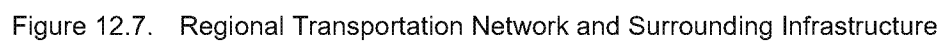
#### **12.5.4.2      *Fine Mesh Modified Traveling Screens***

##### **12.5.4.2.1      *2.0 mm Dual-Flow Fine Mesh Screen Conversion***

The installation of 2.0 mm dual-flow fine mesh screens in the existing CWIS would not directly increase unsafe working conditions. However, the continuous operation of the traveling water screens would require additional operation and maintenance worker hours when compared to existing conditions, increasing the potential for worker accidents and injuries. No other impacts to safety are anticipated with the use of this technology.

#### **12.5.4.2.2     0.5 mm Fine Mesh Screen in an Expanded Cooling Water Intake Structure**

Similar to the 2.0 mm dual-flow fine mesh conversion, the continuous operation of the traveling water screens and increase in the number of screens under the 0.5 mm fine mesh alternative would require additional operation and maintenance worker hours, increasing the potential for worker accidents and injuries. In addition, under the proposed design, the expansion of the CWIS would extend 125 feet upstream and 125 feet downstream from the current structure boundaries. It will also extend approximately 17 feet further into the river. This expansion would result in a very minor increase to potential safety hazards for barges and recreational boaters, as slightly more of the river would be obstructed, increasing the possibility of watercraft collisions with the CWIS. However, the width of the Missouri River at the CWIS is just over 1,500 feet. The 17 additional feet the CWIS would extend into the river would be insignificant and would not impact the ability of boats and barges to safely pass.



### 12.5.5 Facility Reliability

The following section provides a discussion of changes to facility reliability associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(v):

*A discussion of facility reliability, including but not limited to facility availability, production of steam, impacts to production based on process unit heating or cooling, and reliability due to cooling water availability*

Electric system reliability is a measure of the ability of the system to deliver power to consumers within accepted standards and in the amount desired. Reliability encompasses two concepts: adequacy and security. Adequacy implies that there are sufficient generation and transmission resources installed and available to meet projected electrical demand, taking into account scheduled and unscheduled outages of system facilities. Security implies that the system will remain intact operationally (i.e., will have sufficient available operating capacity) even after outages or other equipment failure. The degree of reliability may be measured by the frequency, duration, and magnitude of adverse effects on consumer service (U.S. Energy Information Administration, 2019).

#### 12.5.5.1 Mechanical Draft Cooling Towers

Studies have been completed to investigate reliability impacts that could potentially result from retrofitting existing once-through facilities to closed-cycle cooling systems. The EPA conducted an analysis to evaluate energy reliability issues due to construction downtime and increased power requirements for closed-cycle auxiliary power and turbine efficiency reduction. Based on this analysis, the EPA concluded that while there may be some reliability concerns in certain locations, the effects of closed-cycle cooling on national energy reliability would be minimal (EPA, 2014).

Similarly, the modeling of five North American Electric Reliability Council reliability regions by EPRI determined that regulation-induced retirements and energy penalties would result in little risk to generation adequacy in some reliability regions, including MISO, while other regions, like the Electricity Reliability Council of Texas, Independent System Operator New England, and New York Independent System Operator, would require billions of dollars of new, unplanned generation in order to maintain adequate reserve margins. EPRI evaluated adequacy impacts for MISO, weighing load against projected capacity. Taking into account regulation-induced plant retirements and energy penalties for plants converting to closed-system cooling, MISO's projected capacity margin remained higher than the target capacity margin of 15.9% that serves as a reserve for contingencies. Additionally, in terms of security impacts for MISO, modeling indicated no major concerns associated with transmission system overload and/or voltage violations under normal operating conditions following the incorporation of the closed-cycle cooling retrofit requirement. All of the transmission system overloads were marginal and likely to be alleviated through appropriate generation re-dispatch (EPRI, 2011b).

At the facility level, the lost energy due to outages during the cooling tower retrofit, the additional auxiliary load, and turbine efficiency loss at the LEC would not be anticipated to compromise the local grid reliability because other facilities belonging to MISO would likely be able to make up for the reduction in generating capacity. However, grid reliability could be impacted in the event multiple MISO facilities have reduced generation due to cooling tower energy penalties, outages, or regulation-induced premature retirements. Coordination with MISO and other regional facilities would be necessary to ensure grid reliability impacts are minimized.

#### **12.5.5.2 Fine Mesh Modified Traveling Screens**

The installation of fine mesh modified traveling screens could allow for staged implementation of new screens for each individual generating unit, and it is expected that the unit outage necessary for conversion would be very short, if not avoidable altogether. Once installed, the operation of the modified CWIS would not result in appreciable changes to facility reliability. Therefore, no significant impacts to facility reliability are anticipated in association with the use of fine mesh modified traveling screens.

#### **12.5.6 Water Consumption**

The following section provides an estimate of changes to water consumption associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(vi)

*Significant changes in consumption of water, including a facility-specific comparison of the evaporative losses of both once-through cooling and closed-cycle recirculating systems, and documentation of impacts attributable to changes in water consumption*

##### **12.5.6.1 Mechanical Draft Cooling Towers**

Consumptive water loss is primarily important for facilities located on freshwater where water availability can be an issue during periods of low flow or droughts (EPRI, 2011a). In a once-through cooling water system, water consumption is negligible, as virtually all of the cooling water withdrawn is returned back to the water source. In contrast, cooling towers consume water through evaporation, as a portion of the circulating water in the cooling tower evaporates in order to cool the remainder of the water. A typical evaporation rate for mechanical draft cooling towers is 10 gpm/MW, representing 50 to 80 percent of the intake flow, depending on the COC (EPRI, 2011c).

Based on estimates provided in the BAT Analysis (Burns and McDonnell, 2018), consumptive water use from operational mechanical draft cooling towers at LEC is estimated to be between 8 and 12 gpm/MW, or up to 720 gal/megawatt-hour. At 100 percent capacity factor, this equates to a maximum of approximately 31,000 gpm of water consumption.

The proposed cooling tower design would rely on groundwater collector wells to supply all make-up water for the closed-cycle system. Groundwater in the vicinity is recharged by surface water—most

notably, the Missouri River. The mean flow of the Missouri River at LEC in recent years is 99,210 cfs, which equates to over 44 million gpm (U.S. Geological Survey, 2019). Compared to the availability of groundwater and surface water resources in the vicinity, the amount of water lost through consumptive water use, even at the maximum rate of approximately 31,000 gpm, would be negligible. Therefore, no significant impacts from water consumption are anticipated.

#### **12.5.6.2 Fine Mesh Modified Traveling Screens**

With the installation of fine mesh modified traveling screens, the current intake flow would be maintained, and cooling water would be returned to the Missouri River. Therefore, the use of this technology would not result in appreciable changes in water consumption.

### **12.5.7 Mitigation**

The following section provides a discussion of potential measures to mitigate non-water quality impacts associated with the utilization of Mechanical Draft Cooling Towers and Fine Mesh Modified Traveling Screens at the LEC, in accordance with §122.21(r)(12)(vii):

*A discussion of all reasonable attempts to mitigate each of these factors.*

#### **12.5.7.1 Mechanical Draft Cooling Towers**

##### **12.5.7.1.1 Cooling Tower Drift**

To reduce the drift and associated PM emissions from cooling towers, drift eliminators are often incorporated into the tower design to remove as many water droplets as practical from the air stream before exiting the tower. The drift eliminators used in cooling towers are shaped materials that collect water droplets as they exit the tower. They rely on inertial separation caused by direction changes while passing through the eliminators (EPRI, 2011a). Efficient drift eliminators are commonly used in cooling towers and are frequently required for permitting. Drift eliminators were included in the cooling tower design at LEC, limiting the drift rate to approximately 0.0005 percent of the circulating water flow rate. With these drift eliminators, PM emissions associated with drift are not expected to have a significant impact on human health or the surrounding environment.

##### **12.5.7.1.2 Visible Plumes, Fogging, and Icing**

Plume abatement technologies are available for cooling towers where visible plumes, fogging, and icing would result in significant safety concerns and/or aesthetic viewshed degradation. Plume abatement reduces visual plumes by reducing the relative humidity of the exhaust air from the towers. Plume abatement can be done various ways, specific to each supplier. Some methods include mixing dry ambient air with the wet air, leaving the tower fill to reduce the moisture in the exhaust air. Other methods include using coils to cool a portion of the water by a dry method to reduce overall evaporation and moisture in the exhaust air.

The BAT Analysis (Burns and McDonnell, 2018) considered the use of both plume abated and non-plume abated cooling towers at the LEC. The screening analysis considered the location of the cooling towers immediately northeast of the plant. However, it was determined that at this location, non-plume abated towers would likely result in significant plume impacts at the plant, presenting safety concerns and potential excessive rime ice development on the transmission lines which would threaten plant operations. Without plume abatement, the cooling towers would need to be located farther northeast from the plant to adequately reduce these concerns.

The BAT Analysis concluded that the additional cost of plume-abated towers would be greater than the cost to relocate the towers a sufficient distance to the northeast. As the location currently proposed for the cooling towers is approximately 0.7 miles northeast of the plant and approximately 0.2 miles northeast of the closest transmission lines, plume impacts are not expected to pose significant safety or operational issues at the plant. Major roads and airports are located at a distance sufficient to disperse most fog or ice forming plumes so that safety impacts are not anticipated. Additionally, visual plume impacts are expected to be low, as the areas surrounding the LEC are predominantly rural and agricultural. For these reasons, it was determined that plume abatement for the cooling towers at the LEC would not be required.

#### **12.5.7.1.3 Noise**

Cooling tower noise consists of two primary components: one is the sound of the fans and fan drives, and the other is the sound of the water splashing down through the tower. Noise abatement technologies used primarily for reducing fan noise may include:

- ▶ Low noise fans and gear boxes,
- ▶ Fan deck barriers,
- ▶ Inlet and outlet attenuation,
- ▶ Building a larger tower to allow use of smaller hp fans and/or reduced fan tip speed, and
- ▶ Cooling tower designs that do not use fans (e.g., natural draft towers).

Noise abatement technologies used primarily for reducing water splashing noise include:

- ▶ Sound walls,
- ▶ Splash attenuation, and
- ▶ Inlet attenuation.

Various combinations of these technologies may be selected, depending on the site conditions, equipment design, noise reduction requirements, and economic considerations. The need for noise abatement is highest if towers must be located near areas with highly restrictive noise codes, such as residential areas (Tetra Tech, 2010a).



With the absence of regulatory noise limits and the significant distance between the proposed cooling towers and the closest sensitive receptors, noise impacts from a cooling tower retrofit at the LEC would be minor. Nuisance noise from the cooling towers would be limited to areas within the LEC property boundary. All sensitive receptors, including residences and recreational areas, are at enough distance that cooling tower noise would attenuate to levels below USEPA guidelines and would be consistent with background day-night noise levels for rural areas. Therefore, noise abatement technologies for the cooling towers at the LEC would not be required.

#### **12.5.7.2      *Fine Mesh Modified Traveling Screens***

The utilization of fine mesh modified traveling screens would not result in any significant non-water quality environmental impacts or other impacts discussed above, and therefore, would not require additional mitigation measures.

## 12.6. SUMMARY

The non-water quality impacts of each entrainment control technology deemed feasible and practical for use at the LEC are summarized in Table 12.11.

**Table 12.11. Summary of Non-Water Quality Impacts Associated with Feasible and Practical Entrainment Control Technologies at LEC**

<b>Non-Water Quality Impacts</b>	<b>Mechanical Draft Cooling Towers</b>	<b>2.0 mm Dual-Flow Fine Mesh Screen Conversion</b>	<b>0.5 mm Fine Mesh Screen in an Expanded CWIS</b>
Energy Consumption	Estimated energy penalty of 38.8 MW during average summer conditions and 23.0 MW during average winter conditions.	No appreciable changes to auxiliary load or energy consumption.	Estimated additional auxiliary load of approximately 0.9 MW for new screen drives and spray pumps.
Air Pollutant Emissions	Increase in direct PM emissions of up to 20 tpy with additional regional emissions associated with replacement energy generation. Minor impacts to human health and the environment.	No reduction in generating capacity or increased emissions resulting from replacement energy generation. No impacts to human health or the environment.	Minor regional emissions associated with replacement energy generation due to reduced generating capacity. Impacts to human health and the environment would be negligible.
Noise	Maximum construction noise of 55.4 dBA and maximum operational noise of 40.4 dBA at closest sensitive receptor. Noise impacts on the surrounding community would be minor.	Maximum construction noise of 56.2 dBA at closest sensitive receptor. Operation would result in minor localized noise increases but would not result in appreciable changes at the distance of any sensitive receptors	Same impacts as 2.0 mm Dual-Flow Fine Mesh Screen Conversion
Safety	Primary concerns associated with vapor plume impacts. Current design proposes cooling towers at a sufficient distance from the plant and major roads, negating the need for plume abatement.	Continuous operation of traveling water screens would require additional operation and maintenance worker hours, increasing the potential for worker accidents and injuries.	Similar impacts as 2.0 mm Dual-Flow Fine Mesh Screen Conversion, with addition of minor increase to potential safety hazards for barges and recreational boaters due to CWIS expansion

<b>Non-Water Quality Impacts</b>	<b>Mechanical Draft Cooling Towers</b>	<b>2.0 mm Dual-Flow Fine Mesh Screen Conversion</b>	<b>0.5 mm Fine Mesh Screen in an Expanded CWIS</b>
Facility Reliability	Lost energy due to outages during retrofit, additional auxiliary load, and turbine efficiency loss would not be anticipated to compromise the local grid reliability as other facilities belonging to MISO could make up for the reduction in generating capacity.	Outage necessary for conversion would be very short, if not avoidable altogether. No significant impacts to facility reliability.	Outage necessary for conversion would be very short, if not avoidable altogether. No significant impacts to facility reliability.
Water Consumption	Maximum consumptive water use rate of approximately 31,000 gpm. Compared to the availability of groundwater and surface water resources in the vicinity, consumptive water use would be negligible.	Current intake flow would be maintained, and cooling water would be returned to the Missouri River. No appreciable changes in water consumption.	Same impacts as 2.0 mm Dual-Flow Fine Mesh Screen Conversion

## 12.7. REFERENCES

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## **13 40 CFR 122.21(R)(13) – PEER REVIEW**

This section provides the names and qualifications of the peer reviewers approved by the MDNR for the § 122.21(r)(10)-(12) reports and provides a summary of the charge questions, reviewer comments, and Ameren team responses.

### **13.1 INTRODUCTION**

Required information to meet the requirements under § 122.21(r)(13) includes the names, credentials, and qualifications of the peer reviewers (i.e. resumes), as well as documentation which provides comments by the Peer Reviews and incorporation of those comments and/or explanation of comments not accepted/addressed (i.e. charge question matrix).

### **13.2 PEER REVIEWERS**

Three Peer Reviewers, one per discipline (biology, engineering, and economics) were selected to review the § 122.21(r)(10) Comprehensive Technical Feasibility and Cost Evaluation Study, § 122.21(r)(11) Benefits Valuation Study, and § 122.21(r)(12) Non-Water Quality and Other Impacts Assessment reports for the LEC (Table 13-1). A list of the selected Peer Reviewers, along with credentials, and qualifications were provided to the MDNR and approved prior to the initiating the review process. (Appendix 13-D.)

Dr. Lawrence W. Barnthouse of LWB Environmental Services, Inc. was selected as the Biology Peer Reviewer. Dr. Barnthouse is currently the President and Principal Scientist for LWB Environmental Services, Inc. Prior to establishing LWB Environmental Services, Dr. Barnthouse worked for 19 years for the Environmental Sciences Division of Oak Ridge National Laboratory and 3 years as a Principal Scientist for McLaren-Hart. Dr. Barnthouse has worked on many projects addressing the impacts of cooling water withdrawals on aquatic populations and communities and has completed 316(b) related research projects for the Electric Power Research Institute (EPRI). He worked with both EPRI and the Utility Water Act Group to provide comments on the proposed 316(b) rules in 2002, 2005, 2008, 2010, and 2011.

J.W. Cuchens, P.E. of Cuchens and Associates was selected as the Engineering Peer Reviewer. Mr. Cuchens served for 42 years as the Principal Engineer of cooling systems with Southern Company before establishing Cuchens and Associates for the last 3 years. With over 45 years of experience in all phases of power plant design, construction and operation with various types of generating units including nuclear, fossil, and co-generation facilities, Mr. Cuchens has been contracted to conduct multiple peer reviews of the § 122.21(r)(10) Comprehensive Technical Feasibility and Cost Evaluation Study and § 122.21(r)(12) Non-Water Quality and Other Impacts Assessment reports. The primary focus of Mr. Cuchens experience over the last 42 years has been on power plant cooling systems which consist of cooling towers, cooling ponds/lakes, steam-surface and air-cooled condensers, air removal/vacuum systems, auxiliary heat exchangers, cooling water sumps/pumps, service water equipment and related piping systems.

Dr. Frank Lupi of Michigan State University was selected as the Economics Peer Reviewer. Dr. Lupi has worked as a visiting, assistant, associate, and full professor at Michigan State University since 1998 primarily with the Department of Agricultural Economics and more recently the Department of Fish and Wildlife. In addition to his teaching responsibilities, Dr. Lupi provides outreach services including, but not limited to, economic evidence and social science expertise for natural resource damage assessments, benefits transfers, valuation of fish kills, assisting with survey and research designs and analysis, and economic effects of hydropower relicensing.

**Table 13-1 Names, Affiliation, and Discipline of Peer Reviewers Selected for the LEC.**

Name	Affiliation	Peer Review Discipline
Lawrence W. Barnthouse	LWB Environmental	Biology
J.W. Cuchens, P.E.	Cuchens and Associates	Engineering
Frank Lupi	Michigan State University	Economics

A full resume for each Peer Reviewer is provided in Appendices 13 A - 13 C.

### 13.3 CHARGE QUESTION MATRICES

A charge question matrix was developed for the biology, engineering, and economics disciplines as part of the LEC peer review process. Each matrix was provided to the associated peer reviewer who was instructed to answer the set of charge questions to guide the report review. Each set of questions included an open-ended question asking the peer reviewer to provide any additional comments/suggestions. These matrices served as the primary documentation for the LEC § 122.21(r)(13) peer review process.

Upon completion of the report reviews and responses to the charge questions, the matrices were provided to ASA and its teaming partner (Wood) cumulatively referred to herein as the "ASA Team". The ASA Team then provided detailed responses to address each comment and/or question. Once addressed, each matrix was returned to the peer reviewers for final acknowledgement as to whether their comments were satisfactorily addressed and incorporated into the appropriate report.

The full Biology ( Table 13-2 ), Engineering (Table 13-3), and Economics matrices (Table 13-4) have been included within this section.

Table 13-2. Engineering Peer Review Charge Question Matrix for the LEC.

Peer Reviewer Name:	Lawrence W. Barnthouse	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
1)	Were the sample collection and processing methods (e.g., timing, location, and frequency of sampling; sampling gear used) employed to collect data used in the Benefits Valuation Study appropriate to meet the scope and requirement in §122.21(r)(11)?	Yes	The Benefits Valuation Study must rely on data provided by the §122.21(r)(9) Entrainment Characterization Study. I have examined this study and find that it fully satisfies the requirements of §122.21(r)(9) with respect to study duration, sample collection methods, sample processing methods, and annual loss calculations.	No further action needed	No further action needed
2)	Are the impingement mortality and entrainment (IM&E) reduction estimation methods used in the analyses appropriate, and are they applied correctly?	Yes	The analyses assume that under baseline conditions there is 100% mortality of entrained and impinged fish. These are reasonable assumptions, given that the traveling screens and debris removal systems were not designed to promote impingement survival and that EPA assumes 100% entrainment mortality unless site-specific data demonstrate that some eggs or larvae survive entrainment. The methods used to calculate the relationship between larval length and the probability of retention on fine-mesh screens are appropriate and have been correctly applied. The method used to estimate impingement survival for the fine-mesh screen alternative is the weakest part of the analysis. Table A-1 of the Benefits Valuation Study shows that there is very little information on impingement survival of the target species, and the range of estimated survival rates for some species and life stages is very high. The Best Professional Judgement-based survival rates listed in Table A-2 are best viewed as approximate values; uncertainty concerning these rates should be addressed through Monte Carlo analysis.	ASA has re-run the Monte Carlo analysis to include a variable for fine mesh screen survival. The results are presented in new figures at the end of the uncertainty section. The additional analysis did not affect the conclusions.	Comment adequately addressed
3)	Were the life history data and methods used to estimate equivalent loss and characterize stock dynamics of sufficient rigor for the purposes of this Study?	Yes	The life history data used to estimate equivalent fishery yield, biomass production foregone, and trophic transfer of biomass production foregone were appropriate and were well-documented.  Effects of entrainment and impingement losses on stock dynamics were not addressed. As stated on page 5-6 of the Benefits Valuation Study, "...the levels of entrainment and impingement at the LEC are low relative to the reproductive potential of each of the Target Species and unlikely to induce population-level effects for any of the species involved." No studies of fish population dynamics in the Missouri River are available to test this assertion, however, a review of peer-reviewed literature adverse impacts of entrainment and impingement on fish populations (Barnthouse 2013; <i>Environmental Science &amp; Policy</i> 31:149-156) concluded that any such impacts are usually very small compared to impacts of harvesting.	No further action needed	No further action needed



Peer Reviewer Name:	Lawrence W. Barnthouse	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
4)	Please discuss whether the authors identified important assumptions and uncertainties and sufficiently considered their potential impact on the results.	Yes	<p>As noted in my response to question 2, survival rates of fish eggs and larvae impinged on fine-mesh screens are highly uncertain. This uncertainty could have been addressed through Monte Carlo analysis, as were uncertainties in natural mortality rates, fishing mortality rates, and other parameters affecting the benefits estimates.</p> <p>An additional qualitative uncertainty that should be discussed is changes in fish community structure (and resultant impingement rates) during the 10 years between the impingement study and the entrainment study. When the impingement study was conducted, Asian carp were still relatively uncommon. By the time the entrainment study was conducted, Asian carp were the dominant species present in the vicinity of the station. As discussed in Section 3 of the benefits analysis, Asian carp compete with other filter feeders such as gizzard shad and may have reduced their abundance. Uncertainty resulting from fish community change cannot be quantified but should be noted in section 6.2 of the text.</p>	ASA has inserted language into the report to qualitatively address the uncertainty associated with fish community structure.	Comment adequately addressed
5)	Were the methods used to estimate the biological benefits of entrainment and impingement reductions (i.e., Equivalent Fishery Yield and Production Foregone) sufficient for the purposes of Benefits Valuation? Are the methods used of sufficient rigor to support an entrainment best technology available (BTA) assessment for this facility?	Yes	The methods used to estimate the biological benefits of the entrainment reduction technologies addressed in the report have been used by EPA in the agency's own benefits analyses and are well-documented in EPRI reports. I believe they are the best available methods for addressing biological benefits of entrainment and impingement reductions.	No further action needed	No further action needed
6)	Does the feasibility evaluation in 122.21(r)(10) appropriately reflect biological considerations of biological effectiveness for fine mesh size based on aquatic organisms intended to be protected by the fine-mesh retrofit?	Yes	The feasibility evaluation provides an excellent discussion of the biological effectiveness of fine-mesh screens. Issues of the relationship between mesh size and larval retention are properly addressed. The effect of through-screen velocity on the survival of retained larvae is adequately addressed. The evaluation persuasively shows that the 0.5 mm mesh screen would be more effective than the 1.0 mm or 2.0 mm screens at retaining the species and lengths of larvae entrained at the Labadie station.	No further action needed	No further action needed
7)	Does the Peer Reviewer have additional comments and/or input regarding whether the biological and estimated losses and benefits valuation sections of 122.21(r)(11) are consistent with and meet the requirements of the Rule? If so, please provide a narrative.	Yes	The documents provided to me are very well-organized and the conclusions are well-supported by the data. I provided a few minor comments and suggestions for change in response to questions 2 and 4, however, my overall conclusion is that the biological benefits analyses included in the 122.21(r)(11) Benefits Valuation Study fully satisfy the requirements of the Rule.	No further action needed	No further action needed

Table 13-3. Engineering Peer Review Charge Question Matrix for the LEC.

Peer Reviewer Name:	J. W. Cuchens, P.E.	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
1)	Does the 122.21(r)(10) report provide a site-specific evaluation of closed-cycle cooling, to the extent required by the Rule, and is it of sufficient rigor to support an entrainment best technology available (BTA) assessment for this station? If not, describe the nature of evaluation needed.	Y/N	The report provides an accurate site specific evaluation of closed cycle cooling system including consideration of various cooling tower technologies. The evaluation of closed cycle cooling included a thorough examination of site specific considerations (space, costs, interferences, performance, etc.) to provide an assessment of CCC system as a valid candidate BTA.	No further action needed	Agreed
2)	Does the 122.21(r)(10) report provide a site-specific evaluation of fine-mesh screens, to the extent required by the Rule, and is it of sufficient rigor to support an entrainment best technology available (BTA) assessment for this station?	Y/N	The report provides a site specific evaluation of fine mesh screening systems including consideration of various screen technologies, screen mesh sizes, and screen intake velocities. The evaluation of closed cycle cooling included a thorough examination of site specific details (fine mesh technologies, retrofit requirements, limited space, permitting, flows velocities, costs, etc.) to provide an accurate assessment of fine mesh screens options which would be a candidate BTA.	No further action needed	Agreed
3)	Please discuss whether important assumptions and uncertainties were identified and their potential impact on results were sufficiently considered in the analysis.	Y/N	Assumptions were identified along with uncertainties.as appropriate. The assumption of cooling pond capacity was considered prudent for conservative use. Sizing TWS for a zero blockage is obviously impractical but the rule removed the blockage factor requirement. The engineering level of detail was considered more than sufficient to identify and address some uncertainties and/or potential impacts on implementation. Cost assumptions & discount factors were applied within the bounds of accuracies required/reflected.	No further action needed	Agreed
4)	Are the compliance cost approaches in 122.21(r)(10) appropriate for what's required by the Rule?	Y/N	Compliance costs (net present value after tax) were developed as required by the rule for technologies evaluated including design/construction, ad-min, permitting, outage time, and O&M costs. Compliance costs developed by B&V and Wood were reviewed for inclusion of major cost components as appropriate	No further action needed	Agreed

Peer Reviewer Name:	J. W. Cuchens, P.E.	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
5)	Did the 122.21(r)(12) report assess all applicable closed-cycle cooling and fine-mesh impacts required by the Rule? If not, list the impacts that need further consideration and nature of additional consideration. Were all reasonable attempts to mitigate each of these impacts discussed? If not, list impacts that need additional mitigation measures and nature of those mitigation measures.	Y/N	The report included assessment of CCS alternative technologies as required by the rule including but not limited to use of natural draft cooling towers, mechanical draft cooling towers, hybrid designs, and various multi-cell arrangements. The report also included assessment of alternative screen technologies as required by the rule including but not limited to fine mesh single/dual flow TWS, fine mesh wedge wire screens, retrofit existing system with fine mesh screens. Each of the alternatives considered required identifying impacts and potential mitigation of impacts ( and CCS with use of natural draft cooling towers, mechanical draft cooling towers, hybrid designs, and various multi-cell arrangements	No further action needed	Agreed
6)	Does the alternate water source evaluation meet the requirements of the Rule? If not, describe why not.	Y/N	The report identified necessary water requirements for each technology considered and the potential sources of various alternative water supplies. The report concluded that insufficient alternative water sources are unavailable to meet the minimum requirements and consequently satisfied the requirements of the rule to have considered such. The report reflected a thorough examination of alternate water resources within a wide boundary from the plant site.	No further action needed	Agreed
7)	Does the Peer Reviewer have additional comments and/or input regarding whether the engineering sections of 122.21(r)(10) and (12) are consistent with and meet the requirements of the Rule? If so, please provide a narrative.	Y/N	See Comments Included Below		

Table 13-4. Economics Peer Review Charge Question Matrix for the LEC.

Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
1)	Are the owner/engineering costs to the Labadie Energy Center (LEC) of entrainment reduction technologies presented in sufficient detail to allow estimation of the social costs associated with the increased cost to the LEC?	Yes		No further action needed.	OK
2)	Were the social costs presented in these reports for each of the proposed entrainment reduction technologies developed in accordance with procedures in Environmental Protection Agency's (EPA's) Economic Analysis for the Final Section 316(b) Existing Facilities Rule, May 2014? If not, are methods consistent with applicable social cost evaluation methods?	Yes		No further action needed.	K
3)	Does the biology evaluation in 122.21(r)(11) provide sufficient input to perform the social benefits evaluation in 122.21(r)(11)?	Yes	The approach is used in many 316b evaluations and provides sufficient information for social benefits evaluation, but since I am not a biologist, I cannot attest to the parameter assumptions that were used in that analysis.	Parameter assumptions were reviewed by the biology peer reviewer. No further action needed	OK
4)	Were the social benefits presented in these reports for each of the proposed entrainment reduction technologies developed in accordance with procedures in EPA's Benefits Analysis for the Final Section 316(b) Existing Facilities Rule, May 2014? If not, are the methods consistent with standard resource economics evaluation methods? If not, provide comments or questions.	Yes		No further action needed.	OK
5)	If there are any key social benefits that should be included in the 122.21(r)(11) section, that have been left out? If so, please list them.  If those benefits were included in the monetization, would the overall assessment of benefits change materially?	No	No key benefits were omitted, and given the biological changes, any unquantified social benefits are highly unlikely to materially change the assessment.	No further action needed.	OK
6)	Section 125.98(f) of the Final Rule indicates that quantitative and qualitative social benefits and costs of available entrainment reduction technologies may be considered in making a Best Technology Available (BTA) determination when such information (on both benefits and costs) has been developed with sufficient rigor.  Are the social costs and benefits presented in these §122.21(r)(10)-(12) reports evaluated with sufficient rigor to be used in the BTA determination? If not, provide comments or questions.	Yes		No further action needed.	OK
7)	Were the data inputs and process used to estimate the	Yes	My additional minor comments speak to this point in more detail,		

Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
	economic value of direct and indirect use benefits scientifically defensible and sufficient for the purposes of Benefits Valuation?		but addressing those comments would be highly unlikely to materially change the assessment.	No further action needed.	OK
8)	Were non-use benefits qualitatively addressed in a scientifically defensible manner sufficient for the purposes of Benefits Valuation?	Yes	I do not endorse all the statements in the report about non-use values, but I do agree with the study assertion that for the projected changes in fish biomass, non-use values are likely “very small or non-existent.”	No further action needed.	OK
9)	Were the data inputs and process used to estimate the life-time economic benefits of each alternative generally consistent with Industry Practices and sufficient for the purposes of Benefits Valuation?	Yes		No further action needed.	OK
10)	Does the Peer Reviewer have additional comments and/or input regarding whether the economic analyses of 122.21(r)(10), (11), and (12) are consistent with and meet the requirements of the Rule? If so, please provide a narrative.	Yes	Additional minor comments submitted as an attachment.	No further action needed.	OK
			<b>The following additional comments apply to the r(10) report</b>		
11)			In table 3-2, the 5.94% cost of capital (discount rate) seems reasonable, but it is not clear what the reference for supporting data is (Ameren Economics)	5.94% is based on Ameren's own historical cost of capital.	OK
12)			Why do the numbers for discount rate and escalation differ in table 3-2 from those in 6-1? The numbers in the B&M report (in appendix table on page 113 of the r10 PDF document) match those of table 3-2.	The value of 6.00% reported in Table 6-1 of r10 for Discount Rate is a typo. Life-cycle cost for screen technologies in section 6 of r10 were calculated with a discount rate of 5.94%. The same percentage used in B&M 2018. The difference between the Capital Cost Escalation Rate is likely attributed to the reliance on the Handy-Whitman Index and the time lapse between B&M calculations and Wood's calculations. All other values are consistent. The final r10 report will correct the error associated with the Discount Rate.	OK
13)			Is the use of different project contingency rates across technologies intentional? Specifically, many places mention a 30% contingency (e.g., Table 6-2 and the Black & Veatch calculations), but some use 15% (e.g., Table 6-5 for the 0.5 mm mesh). The various contingencies for cooling towers in the Burns and McDonnell calculations (PDF pages 82-83, B&M	The difference between the contingency values is attributed to the firm providing the estimate. B&V use 30%, B&M used 20% and Wood used 15%. Wood cited the dollar values calculated by B&M	OK, as it be highly unlikely to materially change the assessment.

Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
			pages 4-4 to 4-5) differ from the contingencies for both screen mesh sizes. I was not clear if this is the result of different firms performing the analyses or due to intended differences by technologies.	and B&V without alteration. Changing the values for consistency was likely to lead to confusion for reviewers. No further action needed.	
14)			In tables presenting annual values for social costs, the annual values are presented as the net present values divided by 30. This approach is not how one annualizes values in economics or finance because it ignores the interest rate when converting between the present values (PV) and annual values (AV). That is, the AV for a PV=\$X would be the fixed amount every year for N years that at r% would give a PV=\$X. It is not PV/N unless the interest rate is 0%. I am aware that this approach has been used in other 316b studies; however, this approach for converting social costs to annual values differs from the approach for social benefits in r(11) which appears to use the typical approach from finance and economics.	To keep social cost estimates consistent with the benefit estimates detailed in the r(11) report, annualized social costs were recalculated utilizing the equation: $Annualized\ cost = \frac{r(NPV)}{1-(1+r)^{-n}}$ Where r is the discount rate and n is the number of years that the analysis is conducted over. In the r(10) report, Table 3-4 (page 18), Table 6-4 (page 35) and Table 6-7 (page 38) will all be updated with the revised annualized cost presented in Table 1 of the Social Cost Report.	OK
15)			Table 3 of the Veritas appendix (PDF p200) presents possible incidence of price increases by household incomes. It does so by using a fixed average amount of energy consumption applied to all household income groups. However, there are many studies that show electricity demand responds to income and that price elasticities can differ by income. The implication is that price increases may disproportionately affect the poor, but not to the extent of the example.	The text is intended to provide an illustrative example of how rate increases affect consumers' wellbeing and translate into social costs. It is not a depiction of the process we use to convert the compliance costs into social costs. The text describing that process is provided in the first paragraph following Table 2. Specifically, the text describes that, "To develop the electricity price increases, the design, construction, and installation costs are allocated over the specified construction and installation time-periods presented in Table 2. Operation and maintenance costs are then added for each year the technology is operational, and the future stream of those costs are discounted by 3 and 7 percent to develop the	OK

Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
				present value estimate for each discount rate.” This approach is used to approximate the social costs associated with the compliance costs being passed on to rate payers.	
16)			Section 2.1 of the Veritas appendix (PDF p201, including footnote 2) argues that consumers equate total willingness to pay across goods. However, theory only suggests that the last dollar spent on each good generates the same increment in value, not all dollars spent. Thus, one cannot infer surplus a good by knowing it for another. The text mentions that estimates from fishing studies suggest the ratio of total willingness to pay versus cost is 1.4, though, as mentioned above, this tells us nothing about surplus value from electricity use. Further, it is unclear if this 1.4 factor was used at all in the social cost computations.	The text is intended to provide an illustrative example of how rate increases affect consumers’ wellbeing and translate into social costs. It is not a depiction of the process we use to convert the compliance costs into social costs. The text describing that process is provided in the first paragraph following Table 2. Specifically, the text describes that, “To develop the electricity price increases, the design, construction, and installation costs are allocated over the specified construction and installation time-periods presented in Table 2. Operation and maintenance costs are then added for each year the technology is operational, and the future stream of those costs are discounted by 3 and 7 percent to develop the present value estimate for each discount rate.” This approach is used to approximate the social costs associated with the compliance costs being passed on to rate payers. Additionally, the reference of a willingness to pay value of 40% more than expenditures in the illustrative example has been removed.	OK
17)			Minor typo: Footnote a of tables 3-4, 6-4 and 6-7 should refer to table 1 of Veritas 2019.	Wood will correct this error in the final report. No further action needed.	OK
18)			Minor typo: On page P16 (PDF p23), the third to last sentence	Wood will correct this error in the	OK

Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
			repeats "life-cycle costs".	final report. No further action needed.	
			<b>The following additional comments apply to the r(11) report</b>		
19)			The standard in economics for valuing recreational fishery benefits is to use non-market valuation methods because there is no primary market for recreational fishing. As such, the sentence on page 5-3 (PDF p36) makes little sense. "Unfortunately, economic value of increased recreational use of the resource is not directly reflected in the primary market – i.e., the market for recreational fishing." That said, the non-market valuation method employed is adequate.	We will delete "...i.e., the market for recreational fishing".	OK
20)			Regarding what to do about recreational catch and release fishing, the source material for the recreational fish value data is EPA chapter A5 (2006). There EPA discussed values for recreationally caught fish, and in that chapter EPA makes no distinction between harvested or released fish in the discussion of the underlying data for the meta-analyses of the value to recreational anglers for catching an additional fish. Inspection of several of the underlying studies shows they did make any distinction either. Thus, the EPA meta-analysis results are for the value of a caught fish, regardless of whether it is released. Thus, I see no basis for assigning released fish a lower value than other fish. That would mean that in the equation on page 5-5 (PDF p38), RFHF =1 not 0.5. This adjustment would not likely to change any overall conclusions regarding the disproportionately large costs compared to benefits.	Our approach was based on the understanding that many of the studies upon which EPA values are based were conducted a number of years ago when catch-and-release were less common. Further, we do not believe that anglers would value a fishery for panfish where they could not keep some of the catch. After all, the motivation for fishing for these species is primarily as food not sport. They would be analogous to meat category in the paper by Carter and Liese (2012) The Economic Value of Catching and Keeping or Releasing Saltwater Sport Fish in the Southeast USA North American Journal of Fisheries Management 32:613–625, which found released meat fish had much lower value than kept fish. That said, we agree that conclusions won't change regardless of what assumption is made.	Perhaps, but the implications of the lower catch and release values should still be implicit in the EPA meta-analysis since, even if it is growing for this species, catch and release is not an altogether new phenomenon. Regardless, any adjustment is unlikely to materially change the assessment.
21)			Again, for released fish, table t-2 (p195) of MDOC (2011) shows catch and harvest results for a segment of the river that appears to be more specific to the LEC region of entrainment. It shows release to harvest ratios are more like 3 to 1 for channel catfish relative the numbers for the whole river, and the release to harvest ratio is also larger in this segment for freshwater drum.	The values we used were from Table 8 reflecting the entire lower river. We chose those from a smaller geographic area because of larger sample size coupled with the fact that individuals not entrained or	OK



Peer Reviewer Name:	Frank Lupi	Facility Name:	Labadie Energy Center		
Question Number	§122.21(r)(10),(11),(12)	Response	Comments (if any)	ASA Team Response	Peer Reviewer Acknowledgement
			Accounting for this difference would not likely to change any overall conclusions regarding the disproportionally large costs compared to benefits.	impinged at the LEC could grow up to be caught in other river reaches. That said, we agree that any differences would not like to change any overall conclusions.	
22)			The MDOC table t-2 (MDOC 2011) also shows that there is a non-trivial amount of sturgeon harvested in this stretch that while sturgeon catch is only 10% of channel catfish, they are likely more valuable to anglers (e.g., EPA 2014). That said, any adjustment for this would likely not be large enough to change the relative magnitudes of the costs and benefits.	We agree that sturgeon are more valuable than catfish. However, sturgeon feed on plant material and detritus. Hence, they would not be appropriate as an equivalent predator.	OK
23)			In the uncertainty analysis, it is suggested that values for fish will be lower in Missouri River due to consumption advisories. Several recreationally important species in some of the studies underlying the EPA meta-analyses were also subject to consumption advisories, so this effect is already partially reflected in the estimates of fish values that are being transferred to the Missouri River. This adjustment would not change any overall conclusions regarding the disproportionally large costs compared to benefits.	Agree that the values are partially reflected in the EPA values. However, the degree to which they are reflected is uncertain and, in our opinion, likely small.	OK
			<b>The following additional comments apply to the r(12) report</b>		
			No additional comments		

**Appendix 2 A**  
**40 CFR 122.21(r)(2) – Source Water Physical Data**

**USGS Hermann MO Station - 06934500**

**Surface Water Quality**

**Missouri River, Annual and Monthly Mean Data**

Table 2 A-1 USGS Hermann MO Station: Surface Water Quality, Missouri River, Annual Mean Data.

Water Year	Nitrate + Nitrite, mg/L N	Discharge, CFS	Suspended Sediment Discharge, Short Tons Per Day	Temperature, ° Celsius	Specific Conductance, Microsiemens p/cm at 25 ° Celsius	Turbidity, Formazin Nephelometric Units (FNU)	Dissolved Oxygen, mg/L	Suspended Sediment Concentration, mg/L
1948			337,400					
1949			896,900					
1950			816,300					
1951			1,160,000					
1952			699,100					
1953			259,200					
1954			188,500					
1955			180,100					
1956			114,700					
1957			182,900					
1958		73,520	409,200					
1959		57,100	271,600					
1960		79,170	333,700					
1961		79,180	340,400					
1962		84,920	372,200					
1963		44,980	179,500					
1964		47,450	278,400					
1965		80,110	531,600					
1966		59,850	163,800					
1967		66,460	225,300					
1968		66,110	131,300					

Water Year	Nitrate + Nitrite, mg/L N	Discharge, CFS	Suspended Sediment Discharge, Short Tons Per Day	Temperature, ° Celsius	Specific Conductance, Microsiemens p/cm at 25 ° Celsius	Turbidity, Formazin Nephelometric Units (FNU)	Dissolved Oxygen, mg/L	Suspended Sediment Concentration, mg/L
1969		107,500	334,600					
1970		84,190	218,700					
1971		77,380	179,700					
1972		71,460	156,800					
1973		140,500	489,400					
1974		114,600	328,700 <sup>1</sup>					
1975		88,140						
1976		68,850						
1977		56,670						
1978		97,160						
1979		91,310						
1980		62,980						
1981		65,670						
1982		100,400						
1983		120,400						
1984		127,000						
1985		105,800						
1986		112,200						
1987		127,400						
1988		66,000						
1989		52,040						
1990		78,720						
1991		55,710						
1992		67,130						
1993		181,800						

Water Year	Nitrate + Nitrite, mg/L N	Discharge, CFS	Suspended Sediment Discharge, Short Tons Per Day	Temperature, ° Celsius	Specific Conductance, Microsiemens p/cm at 25 ° Celsius	Turbidity, Formazin Nephelometric Units (FNU)	Dissolved Oxygen, mg/L	Suspended Sediment Concentration, mg/L
1994		109,900						
1995		123,500						
1996		99,240						
1997		121,500						
1998		117,000						
1999		135,700						
2000		57,840						
2001		85,200						
2002		63,860						
2003		45,130						
2004		68,450						
2005		73,420						
2006		41,690		21.44 <sup>1</sup>	667.5 <sup>1</sup>	84.8 <sup>1</sup>	8.50 <sup>1</sup>	
2007		79,080		20.08 <sup>1</sup>	536.7 <sup>1</sup>	199 <sup>1</sup>	7.63 <sup>1</sup>	
2008		114,600		18.14 <sup>1</sup>	443.8 <sup>1</sup>	222 <sup>1</sup>	7.77 <sup>1</sup>	
2009		94,340	167,300	19.30 <sup>1</sup>	548.0 <sup>1</sup>	225 <sup>1</sup>	7.65 <sup>1</sup>	537.5
2010		148,400	271,400	19.91 <sup>1</sup>	485.9 <sup>1</sup>	209 <sup>1</sup>	7.01 <sup>1</sup>	563.3
2011		139,200	156,100	15.74	705.0 <sup>1</sup>	119	7.35 <sup>1</sup>	335.3
2012		70,630	49,990	16.54	671.0 <sup>1</sup>	72.4	7.63 <sup>1</sup>	197.7
2013		73,920	106,300	14.57	635.9 <sup>1</sup>	99.7	7.94 <sup>1</sup>	294.1
2014		62,490	114,600	15.95	691.9	164	9.53	413.1
2015	1.610 <sup>1</sup>	101,600	200,700	14.61	592.0	172	9.36	471.9
2016	2.570	110,200		15.96	625.1	176	8.94	

Water Year	Nitrate + Nitrite, mg/L N	Discharge, CFS	Suspended Sediment Discharge, Short Tons Per Day	Temperature, ° Celsius	Specific Conductance, Microsiemens p/cm at 25 ° Celsius	Turbidity, Formazin Nephelometric Units (FNU)	Dissolved Oxygen, mg/L	Suspended Sediment Concentration, mg/L
2017	2.238	91,420		16.68	690.4	108	9.31	
2018	2.242	80,660		15.84	742.4	100	9.2	

Note: Blank fields, not available.

<sup>1</sup> Annual mean calculated from fewer than 300 sampling days.

Table 2 A-2 Nitrate Plus Nitrite, Water, In Situ, Milligrams Per Liter as Nitrogen.

YEAR	Monthly mean in mg/l as N (Calculation Period: 2015-03-01 - > 2018-12-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015			1.380	1.402	2.205		1.132	1.360	1.907	2.020	1.969	2.855
2016	2.741	2.825	3.707	3.275	3.457	3.207	2.212	1.140	0.891	1.952	2.213	2.629
2017	2.697	2.565	2.757	2.600	3.142	2.993	1.748	0.823	0.787	1.781	1.860	1.704
2018	1.720	1.744	2.165	4.185	2.665	2.370	3.242	1.442	1.680	2.394	2.077	2.255
Mean of Monthly NO <sub>3</sub> + NO <sub>2</sub>	2.39	2.38	2.5	2.87	2.87	2.86	2.08	1.19	1.32	2.04	2.03	2.36

Note: Blank fields, not available.

Table 2 A-3 Discharge, Cubic Feet Per Second (CFS).

YEAR	Monthly mean in ft <sup>3</sup> /s (Calculation Period: 1928-10-01 - > 2018-12-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1928										41,070	134,100	66,740
1929	43,950	36,810	155,400	226,700	226,700	255,700	112,900	43,150	28,120	37,140	46,820	20,850
1930	31,490	76,210	74,570	64,420	107,500	86,260	46,930	31,920	43,630	33,680	34,220	30,110
1931	19,190	33,910	38,400	48,960	47,560	56,060	40,700	25,900	36,670	38,790	90,600	66,100
1932	73,570	50,120	65,650	71,610	60,350	122,300	104,100	64,240	36,190	25,250	25,470	31,540
1933	44,420	30,760	52,910	77,440	110,500	82,920	65,330	33,520	40,960	31,890	21,990	25,290
1934	16,570	28,470	41,310	39,440	31,930	38,770	33,600	19,180	28,790	27,980	39,350	45,550
1935	37,630	41,570	68,180	50,810	133,300	320,600	124,600	37,780	33,110	23,170	46,810	33,440
1936	15,150	31,530	93,630	54,780	55,450	56,620	33,560	18,200	30,930	33,450	34,220	20,360
1937	47,050	92,250	78,620	63,460	78,640	109,000	85,720	46,320	21,830	15,480	18,040	12,110
1938	18,610	33,130	61,430	88,710	115,300	112,800	99,440	53,580	50,050	34,840	31,330	23,530
1939	21,340	33,690	77,160	126,400	59,130	95,950	69,550	42,780	22,540	15,170	16,630	17,250
1940	6,827	12,280	36,480	42,310	50,110	56,650	35,960	49,180	32,940	18,580	18,650	16,770
1941	41,390	40,460	28,290	93,660	42,830	114,300	55,340	32,510	68,310	177,000	126,500	53,730
1942	38,550	69,060	77,750	93,350	162,600	201,900	125,300	54,880	77,550	49,850	52,840	67,680
1943	61,940	54,000	52,420	119,600	231,400	249,700	118,600	55,960	42,810	40,670	41,070	30,120
1944	25,470	35,500	103,200	243,300	185,000	149,000	126,700	95,510	75,690	55,910	45,710	55,840
1945	33,280	62,410	176,600	236,600	176,700	221,000	132,200	61,550	57,600	66,520	38,150	19,450
1946	75,920	56,630	83,040	66,390	79,060	69,930	69,070	64,620	53,450	61,760	95,150	42,910
1947	27,420	30,480	76,600	246,900	109,300	306,000	195,100	56,250	44,980	46,560	51,160	34,020
1948	32,600	36,650	152,300	97,540	71,390	138,500	152,000	95,760	48,280	45,210	53,310	29,760
1949	69,800	116,700	157,600	149,200	87,020	169,900	110,700	52,860	75,600	79,810	42,930	42,280
1950	71,120	55,140	66,820	130,500	149,500	128,500	139,400	119,500	77,760	72,130	54,370	24,140
1951	30,460	58,230	98,240	165,800	150,100	230,800	445,200	130,300	208,900	102,800	117,800	57,920
1952	53,950	90,980	138,500	253,200	144,000	95,670	78,800	58,090	48,600	38,240	40,200	26,740
1953	24,670	42,370	71,920	89,180	94,750	84,020	67,160	43,850	40,250	38,450	32,550	25,020



YEAR	Monthly mean in ft <sup>3</sup> /s (Calculation Period: 1928-10-01 - > 2018-12-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1954	16,320	26,290	36,080	42,130	53,930	83,020	41,680	54,030	40,060	54,780	28,940	25,580
1955	33,740	56,660	75,070	54,330	50,400	60,680	52,740	34,450	39,730	57,450	26,330	15,650
1956	18,030	18,870	28,140	36,490	42,840	42,830	52,560	44,460	36,020	32,990	20,900	16,960
1957	16,070	21,910	28,720	61,000	98,400	99,290	79,930	43,050	43,370	46,830	33,610	34,430
1958	24,150	32,120	103,800	73,240	73,990	71,640	179,800	127,200	76,310	52,770	43,620	24,530
1959	25,120	58,860	71,550	72,320	95,020	77,380	59,770	55,200	49,690	96,820	37,970	32,180
1960	52,950	49,020	67,740	213,500	139,000	79,970	75,720	52,670	52,690	41,400	44,580	28,970
1961	22,340	29,710	107,000	124,500	196,600	78,950	80,490	55,280	137,700	80,410	144,300	45,110
1962	46,980	121,600	132,300	104,100	60,130	107,900	75,650	51,030	55,490	60,150	43,450	24,710
1963	17,350	25,620	69,170	45,800	75,080	52,660	45,250	40,760	37,800	36,680	38,780	17,060
1964	18,130	19,250	22,810	80,920	63,250	121,000	59,690	41,070	52,240	38,170	43,770	24,730
1965	43,740	37,940	99,460	137,300	61,870	111,400	147,100	56,540	159,500	84,050	54,990	44,980
1966	44,250	64,740	56,710	77,600	71,100	73,250	52,940	50,630	43,750	41,620	42,270	27,660
1967	21,570	27,480	29,910	83,480	66,590	228,800	118,900	57,520	52,460	73,050	84,520	65,110
1968	33,740	62,470	51,330	81,930	79,480	69,590	59,450	83,270	49,890	62,390	76,420	66,380
1969	69,980	94,530	109,000	175,800	126,100	140,100	195,200	78,510	95,790	140,700	76,030	47,840
1970	31,050	41,850	55,050	119,400	137,400	137,800	53,890	59,640	109,000	99,890	78,980	50,520
1971	50,860	84,590	108,400	64,920	89,330	106,300	76,630	60,600	58,170	60,120	74,050	86,050
1972	47,780	39,320	60,610	81,510	116,400	71,540	63,350	70,380	85,200	68,060	134,000	66,550
1973	129,000	135,300	267,500	333,400	192,100	113,400	92,290	72,910	84,410	221,900	127,600	127,400
1974	114,700	115,600	129,100	87,050	143,800	132,600	55,880	53,650	64,250	51,460	104,400	54,780
1975	58,920	103,100	108,300	124,000	88,110	112,500	82,570	80,750	92,730	79,590	81,530	68,900
1976	40,190	49,540	80,480	101,100	103,800	70,000	59,470	47,250	43,760	48,190	45,640	36,060
1977	21,560	34,150	42,840	50,660	53,720	83,470	77,150	58,670	128,400	93,350	125,100	47,200
1978	32,830	26,710	169,800	173,200	145,400	88,500	90,990	79,900	89,050	67,760	77,620	54,110
1979	32,390	67,340	192,800	158,500	116,600	94,390	99,200	70,260	63,340	50,900	70,920	54,960
1980	41,550	49,360	73,320	124,500	58,970	83,450	48,860	49,910	50,700	45,260	47,030	40,750

YEAR	Monthly mean in ft <sup>3</sup> /s (Calculation Period: 1928-10-01 - > 2018-12-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	26,230	30,030	30,910	51,390	97,480	117,900	153,300	89,730	54,830	52,730	59,750	49,080
1982	37,450	136,800	111,200	76,770	124,400	223,500	135,000	100,100	103,400	72,680	80,840	178,900
1983	77,940	90,670	119,100	233,600	204,200	156,000	109,300	63,470	56,770	61,360	103,100	84,000
1984	50,600	92,710	169,500	248,400	205,500	206,700	164,100	71,990	67,410	78,200	111,300	85,940
1985	96,820	124,400	171,700	122,800	106,400	152,700	71,770	81,990	68,530	156,000	152,700	116,300
1986	61,030	91,410	88,880	107,300	155,500	99,990	132,400	76,070	107,100	286,700	149,700	133,100
1987	71,280	80,110	146,800	177,800	123,600	105,900	99,330	77,300	72,110	53,730	63,930	98,760
1988	67,450	75,410	84,420	105,800	64,740	46,150	44,010	42,790	45,280	46,660	47,280	37,250
1989	36,850	39,120	52,970	57,540	47,710	57,020	48,900	56,410	97,110	44,860	34,260	21,740
1990	31,010	48,730	95,370	89,980	183,600	183,500	89,710	74,700	45,450	45,560	29,400	30,970
1991	48,930	48,920	42,310	80,810	115,900	92,640	52,840	39,540	40,720	40,810	35,130	44,960
1992	39,350	50,860	62,680	100,000	62,210	59,600	119,100	109,000	80,980	61,050	118,200	146,000
1993	108,000	96,640	149,200	197,800	194,900	176,000	376,300	306,600	243,500	169,000	127,900	91,390
1994	62,380	86,920	107,000	173,200	174,000	127,300	85,750	57,140	56,260	49,160	82,220	64,080
1995	67,750	66,510	63,900	109,400	313,000	282,300	178,000	118,900	83,030	79,190	85,280	58,130
1996	44,370	52,840	58,710	82,620	194,500	199,600	132,300	110,400	92,020	97,000	135,500	100,200
1997	61,600	126,600	146,700	193,800	154,800	155,800	107,700	90,260	91,420	93,950	96,170	103,000
1998	89,850	91,360	148,400	189,300	111,000	158,400	130,900	100,600	91,140	173,000	174,800	106,800
1999	77,160	124,000	107,100	172,200	220,400	172,800	147,200	83,940	69,700	66,650	63,820	57,860
2000	49,210	46,860	54,730	51,160	54,600	75,500	70,330	56,840	45,940	46,940	47,800	30,040
2001	32,830	84,590	123,700	118,700	116,400	206,200	97,450	61,240	59,410	57,830	44,680	43,600
2002	34,880	54,450	44,960	65,810	184,500	100,800	47,810	44,480	41,610	42,670	40,360	28,910

YEAR	Monthly mean in ft <sup>3</sup> /s (Calculation Period: 1928-10-01 - > 2018-12-31)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	25,540	29,000	38,130	47,170	81,730	65,030	53,390	37,920	50,850	38,500	44,660	48,240
2004	51,040	38,740	103,700	70,600	94,400	107,200	87,790	72,820	62,070	42,640	70,610	65,000
2005	119,500	102,700	47,200	65,800	73,500	128,000	56,580	57,680	55,420	49,250	26,790	28,190
2006	30,100	30,540	34,460	50,960	72,360	48,250	40,970	42,660	44,790	35,230	24,820	33,720
2007	39,460	51,900	80,230	106,700	200,900	130,300	107,000	80,280	55,930	71,040	42,760	46,160
2008	53,660	80,190	144,800	171,200	138,800	231,200	168,200	87,760	141,500	78,910	68,460	55,240
2009	60,070	61,860	92,290	126,000	186,200	158,000	95,230	81,770	66,250	122,200	134,200	75,770
2010	101,400	95,640	171,800	159,800	202,900	230,400	194,400	138,500	151,300	102,800	86,900	66,020
2011	52,330	92,250	140,400	144,900	179,300	217,000	234,700	208,300	142,000	82,490	70,560	76,850
2012	52,720	63,620	95,450	110,400	93,460	61,680	48,020	45,130	46,950	46,200	46,670	33,070
2013	28,890	36,440	78,050	133,700	112,000	176,400	59,410	88,960	47,170	44,760	49,700	34,460
2014	35,170	37,240	37,480	69,170	60,310	120,800	89,150	63,810	108,500	120,900	66,390	57,850
2015	43,160	52,990	51,280	72,270	133,200	238,800	204,800	103,500	71,230	56,930	84,120	202,700
2016	139,300	88,830	70,920	80,420	172,100	131,500	105,000	84,980	102,800	75,690	54,410	47,840
2017	53,500	53,170	52,730	141,200	232,200	124,100	105,000	92,670	61,290	80,190	57,840	49,160
2018	40,620	56,380	82,750	84,860	95,960	93,220	115,200	90,700	119,800	167,900	117,200	119,600
Mean of Monthly Discharge	47,400	60,600	89,000	114,000	119,000	128,000	102,000	70,100	69,500	68,500	66,900	53,800

Note: Blank fields, not available.

Table 2 A-4 Suspended Sediment Discharge, Short Tons Per Day.

YEAR	Monthly mean in tons/day (Calculation Period: 1948-08-01 - > 2015-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1948								634,000	208,800	152,500	236,800	69,350
1949	326,600	722,800	1,518,000	2,267,000	627,800	2,737,000	1,160,000	343,200	659,100	416,200	91,950	84,430
1950	186,000	149,700	229,000	1,952,000	2,163,000	1,357,000	1,782,000	988,700	347,200	604,400	190,000	43,590
1951	36,990	298,700	1,082,000	2,113,000	1,932,000	3,062,000	1,942,000	1,157,000	1,443,000	449,300	471,500	98,220
1952	77,950	318,300	1,229,000	2,561,000	804,900	1,004,000	1,063,000	190,800	140,300	77,360	144,300	35,180
1953	20,370	97,700	351,100	529,300	595,500	674,600	433,900	99,520	47,180	51,710	51,910	26,230
1954	8,734	43,100	127,300	104,800	364,400	990,600	90,230	311,000	92,970	406,100	50,940	23,840
1955	71,670	412,300	268,300	240,000	144,300	240,900	182,500	66,590	72,800	157,700	41,190	14,410
1956	13,540	16,710	88,780	126,900	206,000	106,800	316,600	175,300	103,600	42,790	22,900	17,980
1957	17,900	38,480	68,050	185,100	403,000	653,900	395,200	147,500	199,000	200,500	84,560	109,600
1958	47,230	127,700	653,700	440,300	568,300	436,100	1,055,000	742,000	408,800	114,000	76,620	28,660
1959	25,600	108,000	266,800	262,400	876,300	580,600	399,300	269,800	237,800	440,300	41,310	26,340
1960	200,800	180,700	371,400	877,500	536,200	568,000	446,400	143,400	178,900	40,430	60,520	22,520
1961	17,420	37,830	827,900	675,600	817,500	404,400	412,100	151,900	600,100	301,300	517,300	37,260
1962	49,510	496,000	825,000	395,400	251,700	878,700	407,000	187,300	146,700	166,300	59,040	19,520
1963	7,392	34,990	474,500	112,300	549,400	315,300	228,700	106,100	61,290	77,660	70,400	18,540
1964	36,470	12,300	43,350	583,400	516,700	1,448,000	217,700	108,600	230,300	105,100	137,600	43,070
1965	231,300	107,000	1,078,000	1,103,000	527,600	994,900	1,104,000	109,000	828,100	216,400	107,000	70,950
1966	59,610	275,700	94,320	187,300	173,400	450,000	130,500	158,600	57,790	59,350	63,140	17,450
1967	10,420	17,820	44,320	358,400	116,700	1,498,000	319,600	90,770	124,200	237,200	118,600	67,920

YEAR	Monthly mean in tons/day (Calculation Period: 1948-08-01 - > 2015-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	37,490	84,040	56,580	176,900	143,700	117,700	232,100	230,900	68,490	189,300	113,500	69,360
1969	115,100	153,200	268,600	899,500	437,500	455,100	997,700	104,400	204,400	372,400	62,540	27,320
1970	14,990	24,540	88,610	452,900	472,000	582,500	36,190	59,940	433,200	193,500	105,000	60,950
1971	73,320	287,500	424,000	85,880	231,100	383,500	186,100	74,330	58,620	73,440	140,100	185,000
1972	50,850	31,730	124,000	184,400	413,700	147,400	124,600	156,300	245,100	101,000	345,300	110,600
1973	577,000	593,200	1,519,000	1,167,000	450,800	288,700	274,800	174,200	286,100	779,000	252,300	265,100
1974	475,600	236,700	247,700	138,200	672,700	717,900	43,360	45,230	57,030			
2008										86,760	35,730	74,440
2009	47,470	63,220	310,900	214,900	508,000	432,600	95,000	98,250	31,330	137,900	148,100	66,810
2010	151,600	105,600	415,200	335,400	381,800	615,500	432,600	175,200	284,200	58,260	41,960	24,800
2011	20,090	93,220	130,200	214,700	314,100	389,200	298,400	190,200	95,790	25,840	12,110	30,320
2012	6,700	23,000	92,370	216,600	116,400	36,310	12,860	12,780	15,400	19,970	15,640	10,070
2013	9,315	16,900	94,250	335,600	173,900	477,600	36,400	71,720	18,810	19,980	19,910	9,032
2014	8,680	13,210	12,260	97,940	82,000	495,600	205,900	84,220	332,600	203,300	23,720	20,090
2015	10,540	19,210	18,600	57,970	395,800	811,500	513,600	239,200	82,920	36,550	107,100	428,800
2016	91,170	67,730	57,990	125,000	535,000	230,100	171,700	140,600				
Mean of Monthly Suspended Sediment Discharge	92,200	156,000	397,000	582,000	514,000	723,000	463,000	218,000	247,000	195,000	119,000	66,400

Note: Blank fields, not available.

**Appendix 4 A**  
**40 CFR 122.21(r)(4) – Source Water Baseline Biological  
Characterization Data**

**Supplemental Data Tables**

**Table 4 A-1 Species Belonging to Carp and Minnow Family Groups Identified by Distinct Morphological Characters (Fuiman et al. 1983) Known to Occur near the LEC.**

Minnow Family Group	Distinctive Larval Character	Fish Common Name	
Group 1	High preanal length	Goldfish Common carp	Grass carp
Group 2	Flattened eye	Speckled chub Silver chub Bluntnose minnow Shoal chub <sup>1</sup>	Sand shiner Suckermouth minnow Bullhead minnow
Group 3	High preanal myomere number (>25)	Central stoneroller Striped shiner	Creek chub Common shiner
Group 4	Midventral stripe	Golden shiner Emerald shiner Mimic shiner	Rosyface shiner Silverband shiner Fathead minnow
Group 5	Scattered breast	Bigmouth shiner	
Group 6	Outlined gut	River shiner Spotfin shiner	Red shiner

<sup>1</sup> The shoal chub was elevated to full species status from the speckled chub species-complex through morphological studies by Eisenhour (1999, 2004) and genetic studies by Underwood et al. (2003). Henceforth, all specimens formerly identified as speckled chub are now identified as shoal chub.

**Appendix 9 A**  
**40 CFR 122.21(r)(9) – Entrainment Characterization Study**

**Supplemental Data Tables**



**Table 9 A-1 List of Fish Taxa Identified Within the Lower Missouri River in the Vicinity of the Labadie Energy Center, 1974-2018.**

Family	Scientific Name	Common Name
Acipenseridae-sturgeons	<i>Acipenser fulvescens</i>	Lake sturgeon
	<i>Scaphirhynchus albus</i>	Pallid sturgeon
	<i>Scaphirhynchus platyrhynchus</i>	Shovelnose sturgeon
	<i>S. albus</i> × <i>S. platyrhynchus</i>	Pallid sturgeon × shovelnose sturgeon
Amiidae-bowfins	<i>Amia calva</i>	Bowfin
Anguillidae-freshwater eels	<i>Anguilla rostrata</i>	American eel
Atherinopsidae-New World silversides	<i>Labidesthes sicculus</i>	Brook silverside
Catostomidae-suckers	<i>Carpionodes carpio</i>	River carpsucker
	<i>Carpionodes cyprinus</i>	Quillback
	<i>Carpionodes velifer</i>	Highfin carpsucker
	<i>Catostomus commersonii</i>	White sucker
	<i>Cycleptus elongatus</i>	Blue sucker
	<i>Hypentelium nigricans</i>	Northern hog sucker
	<i>Ictiobus bubalus</i>	Smallmouth buffalo
	<i>Ictiobus cyprinellus</i>	Bigmouth buffalo
	<i>Ictiobus niger</i>	Black buffalo
	<i>Minytrema melanops</i>	Spotted sucker
	<i>Moxostoma carinatum</i>	River redhorse
	<i>Moxostoma erythrurum</i>	Golden redhorse
	<i>Moxostoma macrolepidotum</i>	Shorthead redhorse
Centrarchidae-sunfishes	<i>Ambloplites rupestris</i>	Rock bass
	<i>Lepomis cyanellus</i>	Green sunfish
	<i>Lepomis gulosus</i>	Warmouth
	<i>Lepomis humilis</i>	Orangespotted sunfish
	<i>Lepomis macrochirus</i>	Bluegill
	<i>Lepomis megalotis</i>	Longear sunfish
	<i>Lepomis punctatus</i>	Spotted sunfish
	<i>Micropterus dolomieu</i>	Smallmouth bass
	<i>Micropterus punctulatus</i>	Spotted bass
	<i>Micropterus salmoides</i>	Largemouth bass
	<i>Pomoxis annularis</i>	White crappie
	<i>Pomoxis nigromaculatus</i>	Black crappie
Clupeidae-herrings	<i>Alosa chrysochloris</i>	Skipjack herring
	<i>Dorosoma cepedianum</i>	Gizzard shad
Cyprinidae-carps and minnows	<i>Campostoma anomalum</i>	Central stoneroller
	<i>Campostoma oligolepis</i>	Largescale stoneroller
	<i>Carassius auratus</i>	Goldfish
	<i>Ctenopharyngodon cf. idella</i>	Grass carp
	<i>Cyprinella lutrensis</i>	Red shiner
	<i>Cyprinella spiloptera</i>	Spotfin shiner
	<i>Cyprinus carpio</i>	Common carp
	<i>Erimystax x-punctatus</i>	Gravel chub
	<i>Hybognathus argyritis</i>	Western silvery minnow
	<i>Hybognathus placitus</i>	Plains minnow
	<i>Hypophthalmichthys molitrix</i>	Silver carp

Family	Scientific Name	Common Name
Cyprinidae-carps and minnows	<i>Hypophthalmichthys nobilis</i>	Bighead carp
	<i>Luxilus chrysocephalus</i>	Striped shiner
	<i>Luxilus cornutus</i>	Common shiner
	<i>Lythrurus umbratilis</i>	Redfin shiner
	<i>Macrhybopsis aestivalis</i>	Speckled chub
	<i>Macrhybopsis gelida</i>	Sturgeon chub
	<i>Macrhybopsis hyostoma</i>	Shoal chub
	<i>Macrhybopsis meeki</i>	Sicklefin chub
	<i>Macrhybopsis storeriana</i>	Silver chub
	<i>Notemigonus crysoleucas</i>	Golden shiner
	<i>Notropis atherinoides</i>	Emerald shiner
	<i>Notropis blennius</i>	River shiner
	<i>Notropis boops</i>	Bigeye shiner
	<i>Notropis buechanani</i>	Ghost shiner
	<i>Notropis dorsalis</i>	Bigmouth shiner
	<i>Notropis rubellus</i>	Rosyface shiner
	<i>Notropis shumardi</i>	Silverband shiner
	<i>Notropis stramineus</i>	Sand shiner
	<i>Notropis volucellus</i>	Mimic shiner
	<i>Notropis wickliffi</i>	Channel shiner
	<i>Phenacobius mirabilis</i>	Suckermouth minnow
	<i>Pimephales notatus</i>	Bluntnose minnow
	<i>Pimephales promelas</i>	Fathead minnow
	<i>Pimephales vigilax</i>	Bullhead minnow
	<i>Platygobio gracilis</i>	Flathead chub
	<i>Semotilus atromaculatus</i>	Creek chub
Esocidae-pikes and	<i>Esox lucius</i>	Northern pike
Fundulidae-topminnows	<i>Fundulus olivaceus</i>	Blackspotted topminnow
	<i>Fundulus zebrinus</i>	Plains killifish
Hiodontidae-mooneyes	<i>Hiodon alosoides</i>	Goldeye
	<i>Hiodon tergisus</i>	Mooneye
Ictaluridae-North American catfishes	<i>Ameiurus melas</i>	Black bullhead
	<i>Ameiurus natalis</i>	Yellow bullhead
Ictaluridae-North American catfishes	<i>Ictalurus furcatus</i>	Blue catfish
	<i>Ictalurus punctatus</i>	Channel catfish
	<i>Noturus flavus</i>	Stonecat
	<i>Noturus gyrinus</i>	Tadpole madtom
	<i>Noturus nocturnus</i>	Freckled madtom
	<i>Pylodictis olivaris</i>	Flathead catfish
Lepisosteidae-gars	<i>Lepisosteus oculatus</i>	Spotted gar
	<i>Lepisosteus osseus</i>	Longnose gar
	<i>Lepisosteus platostomus</i>	Shortnose gar
Moronidae-temperate basses	<i>Morone chrysops</i>	White bass
	<i>Morone mississippiensis</i>	Yellow bass
	<i>Morone saxatilis</i>	Striped bass
	<i>M. saxatilis</i> × <i>M. chrysops</i>	Striped bass × white bass
Osmeridae-smelts	<i>Osmerus mordax</i>	Rainbow smelt
Percidae-perches	<i>Etheostoma nigrum</i>	Johnny darter
	<i>Etheostoma tetrazonum</i>	Missouri saddled darter
	<i>Etheostoma zonale</i>	Banded darter

Family	Scientific Name	Common Name
	<i>Percina caprodes</i>	Logperch
	<i>Percina maculata</i>	Blackside darter
	<i>Percina phoxocephala</i>	Slenderhead darter
	<i>Percina shumardi</i>	River darter
Percidae-perches	<i>Sander canadensis</i>	Sauger
	<i>Sander vitreus</i>	Walleye
	<i>S. canadensis</i> × <i>S. vitreus</i>	Saugeye (Sauger × walleye)
Petromyzontidae-lampreys	<i>Ichthyomyzon castaneus</i>	Chestnut lamprey
	<i>Ichthyomyzon unicuspis</i>	Silver lamprey
Poeciliidae-liverbearers	<i>Gambusia affinis</i>	Western mosquitofish
Polyodontidae-paddlefishes	<i>Polyodon spathula</i>	Paddlefish
Sciaenidae-drums and croakers	<i>Aplodinotus grunniens</i>	Freshwater drum

**Table 9 A-2 Sampling Interval Density, Daytime and Nighttime Mean Density, and Event Mean Density of Each Taxon and Development Stage Collected During 2015 and 2016 Entrainment Sampling Conducted at the LEC.**

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	3/3/2015	1	No fish collected	--	--	--	--	--	--	--	
2015	3/10/2015	2	No fish collected	--	--	--	--	--	--	--	
2015	3/17/2015	3	No fish collected	--	--	--	--	--	--	--	
2015	3/24/2015	4	Unidentifiable fish	EGG	9.1	0	4.5	0	0	2.3	
2015	3/31/2015	5	No fish collected	--	--	--	--	--	--	--	
2015	4/7/2015	6	Shoal chub	OLD	0	0	0	9.6	0	2.4	
2015	4/7/2015	6	Unidentifiable fish	EGG	0	0	0	0	9.8	2.5	
2015	4/14/2015	7	Carp sucker/buffalo fish	YSL	9.8	0	4.9	9.4	0	4.8	
2015	4/14/2015	7	Unidentifiable fish	EGG	29.3	0	14.7	0	0	7.3	
2015	4/21/2015	8	Buffalo fish	LAR	28.8	9.7	19.2	0	37.8	19.1	
2015	4/21/2015	8	Carp sucker/buffalo fish	LAR	57.5	87.2	72.3	87.9	56.7	72.3	
2015	4/21/2015	8	Carp sucker/buffalo fish	YSL	0	77.5	38.8	0	0	19.4	
2015	4/21/2015	8	Carp suckers	YSL	0	0	0	9.8	0	2.5	
2015	4/21/2015	8	Redhorse suckers	LAR	9.6	0	4.8	0	18.9	7.1	
2015	4/21/2015	8	Redhorse suckers	YSL	0	9.7	4.8	0	9.4	4.8	
2015	4/21/2015	8	Suckers	LAR	105.5	0	52.8	0	0	26.4	
2015	4/21/2015	8	Unidentifiable fish	EGG	0	0	0	9.8	0	2.5	
2015	4/21/2015	8	Unidentifiable fish	LAR	57.5	96.9	77.2	39.1	47.2	60.2	
2015	4/21/2015	8	Walleye	LAR	9.6	0	4.8	0	0	2.4	
2015	4/21/2015	8	White sucker	LAR	0	0	0	29.3	0	7.3	

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	4/21/2015	8	White sucker	YSL	0	9.7	4.8	9.8	0	4.9	4.9
2015	4/28/2015	9	Carp sucker/buffalofish	LAR	0	0	0	0	9.7	4.8	2.4
2015	4/28/2015	9	Carp sucker/buffalofish	PYSL	29.3	19.5	24.4	0	0	0	12.2
2015	4/28/2015	9	Carp sucker/buffalofish	YSL	0	0	0	9.8	0	4.9	2.5
2015	4/28/2015	9	Carp suckers	YSL	9.8	0	4.9	0	0	0	2.5
2015	4/28/2015	9	Redhorse suckers	PYSL	39.1	9.8	24.5	9.8	9.7	9.8	17.1
2015	4/28/2015	9	Redhorse suckers	YSL	48.9	9.8	29.4	19.5	0	9.8	19.6
2015	4/28/2015	9	Unidentifiable fish	EGG	0	9.8	4.9	0	9.7	4.8	4.9
2015	4/28/2015	9	Unidentifiable fish	LAR	19.6	117.2	68.4	0	48.5	24.2	46.3
2015	4/28/2015	9	Unidentifiable fish	PYSL	0	0	0	48.9	0	24.4	12.2
2015	4/28/2015	9	Walleye/sauger	PYSL	0	9.8	4.9	0	9.7	4.8	4.9
2015	5/5/2015	10	Buffalofish	PYSL	0	9.8	4.9	0	28.7	14.3	9.6
2015	5/5/2015	10	Carp sucker/buffalofish	LAR	0	0	0	0	143.5	71.8	35.9
2015	5/5/2015	10	Carp sucker/buffalofish	PYSL	136.9	146.6	141.8	86.9	0	43.5	92.6
2015	5/5/2015	10	Carp suckers	PYSL	0	0	0	9.7	0	4.8	2.4
2015	5/5/2015	10	Redhorse suckers	LAR	0	0	0	0	9.6	4.8	2.4
2015	5/5/2015	10	Redhorse suckers	PYSL	19.6	9.8	14.7	29	9.6	19.3	17
2015	5/5/2015	10	Suckers	PYSL	9.8	0	4.9	0	0	0	2.5
2015	5/5/2015	10	Unidentifiable fish	LAR	283.7	0	141.8	0	86.1	43	92.4
2015	5/5/2015	10	Unidentifiable fish	PYSL	0	449.7	224.8	154.4	0	77.2	151
2015	5/5/2015	10	Walleye/sauger	PYSL	9.8	0	4.9	0	0	0	2.5
2015	5/12/2015	11	Carp sucker/buffalofish	PYSL	301.8	0	150.9	0	0	0	75.5

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	5/12/2015	11	Common carp	PYSL	0	0	0	316.3	0	158.2	79.1
2015	5/12/2015	11	Goldeye	PYSL	0	0	0	0	153.2	76.6	38.3
2015	5/12/2015	11	Goldeye/mooneye	PYSL	0	0	0	0	153.2	76.6	38.3
2015	5/12/2015	11	Grass carp	YSL	0	0	0	0	306.4	153.2	76.6
2015	5/12/2015	11	Silver/bighead carp	LAR	70310.1	0	35155.1	0	0	0	17577.5
2015	5/12/2015	11	Silver/bighead carp	PYSL	3319.4	64308.7	33814	49652.1	35852.4	42752.2	38283.2
2015	5/12/2015	11	Silver/bighead carp	YSL	1207	1236.7	1221.8	2846.3	1685.4	2265.9	1743.9
2015	5/12/2015	11	Unidentifiable fish	EGG	0	0	0	0	153.2	76.6	38.3
2015	5/12/2015	11	Unidentifiable fish	LAR	0	6801.9	3400.9	11068.9	8120.4	9594.6	6497.8
2015	5/12/2015	11	Unidentifiable fish	PYSL	9052.8	0	4526.4	0	0	0	2263.2
2015	5/12/2015	11	Walleye	PYSL	301.8	0	150.9	0	0	0	75.5
2015	5/19/2015	12	Buffalofish	PYSL	0	0	0	19.5	0	9.8	4.9
2015	5/19/2015	12	Carp sucker/buffalofish	LAR	0	0	0	48.9	0	24.4	12.2
2015	5/19/2015	12	Carp sucker/buffalofish	PYSL	0	28.8	14.4	0	195.5	97.8	56.1
2015	5/19/2015	12	Carp suckers	YSL	0	0	0	9.8	0	4.9	2.5
2015	5/19/2015	12	Common carp	PYSL	0	0	0	0	39.1	19.6	9.8
2015	5/19/2015	12	Freshwater drum	EGG	37.9	76.9	57.4	0	0	0	28.7
2015	5/19/2015	12	Freshwater drum	PYSL	0	0	0	0	19.6	9.8	4.9
2015	5/19/2015	12	Goldeye	PYSL	189.5	67.3	128.4	68.4	176	122.2	125.3
2015	5/19/2015	12	Goldeye	YSL	0	9.6	4.8	0	0	0	2.4
2015	5/19/2015	12	Grass carp	YSL	0	38.5	19.2	0	0	0	9.6
2015	5/19/2015	12	Herrings-shads	PYSL	0	9.6	4.8	0	0	0	2.4

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	5/19/2015	12	Minnows	LAR	0	0	0	479	567	523	261.5
2015	5/19/2015	12	Silver carp	PYSL	37.9	0	18.9	0	0	0	9.5
2015	5/19/2015	12	Silver/bighead carp	PYSL	9552.2	2202.2	5877.2	185.7	1603.4	894.6	3385.9
2015	5/19/2015	12	Silver/bighead carp	YSL	0	0	0	0	19.6	9.8	4.9
2015	5/19/2015	12	Unidentifiable fish	LAR	2198.5	0	1099.2	488.7	743	615.9	857.5
2015	5/19/2015	12	Unidentifiable fish	PYSL	0	134.6	67.3	0	0	0	33.6
2015	5/19/2015	12	Walleye/sauger	PYSL	0	0	0	9.8	0	4.9	2.5
2015	5/19/2015	12	White sucker	PYSL	75.8	19.2	47.5	9.8	39.1	24.5	36
2015	5/26/2015	13	Buffalofish	YSL	0	79.5	39.8	307.5	0	153.8	96.8
2015	5/26/2015	13	Carp sucker/buffalofish	YSL	635.2	0	317.6	307.5	0	153.8	235.7
2015	5/26/2015	13	Carp suckers	YSL	0	318.2	159.1	0	0	0	79.5
2015	5/26/2015	13	Common carp	PYSL	79.4	0	39.7	0	0	0	19.9
2015	5/26/2015	13	Freshwater drum	PYSL	0	0	0	0	74.1	37	18.5
2015	5/26/2015	13	Gizzard shad	PYSL	158.8	318.2	238.5	307.5	444.4	375.9	307.2
2015	5/26/2015	13	Goldeye	PYSL	0	79.5	39.8	0	74.1	37	38.4
2015	5/26/2015	13	Goldeye	YSL	158.8	159.1	158.9	461.3	148.1	304.7	231.8
2015	5/26/2015	13	Grass carp	YSL	0	79.5	39.8	0	0	0	19.9
2015	5/26/2015	13	Herrings-shads	LAR	0	79.5	39.8	0	0	0	19.9
2015	5/26/2015	13	Herrings-shads	PYSL	238.2	0	119.1	153.8	0	76.9	98
2015	5/26/2015	13	Minnows	LAR	4684.6	0	2342.3	1383.9	1037	1210.5	1776.4
2015	5/26/2015	13	Minnows group 2	PYSL	0	0	0	153.8	0	76.9	38.5
2015	5/26/2015	13	Silver/bighead carp	LAR	17150.3	15112.6	16131.5	15529.9	9333.2	12431.5	14281.5

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	5/26/2015	13	Silver/bighead carp	PYSL	0	7635.8	3817.9	9840.7	3481.4	6661.1	5239.5
2015	5/26/2015	13	Silver/bighead carp	YSL	7463.6	1431.7	4447.7	768.8	444.4	606.6	2527.1
2015	5/26/2015	13	Unidentifiable fish	EGG	0	0	0	307.5	0	153.8	76.9
2015	5/26/2015	13	Unidentifiable fish	LAR	79.4	1829.4	954.4	1691.4	962.9	1327.2	1140.8
2015	6/2/2015	14	Buffalofish	PYSL	0	159.8	79.9	0	0	0	40
2015	6/2/2015	14	Common carp	PYSL	0	159.8	79.9	0	0	0	40
2015	6/2/2015	14	Freshwater drum	EGG	319.5	0	159.8	0	0	0	79.9
2015	6/2/2015	14	Gizzard shad	LAR	2077	0	1038.5	153.2	0	76.6	557.5
2015	6/2/2015	14	Gizzard shad	PYSL	0	2236.6	1118.3	842.4	995.6	919	1018.6
2015	6/2/2015	14	Goldeye	PYSL	0	159.8	79.9	306.3	76.6	191.4	135.7
2015	6/2/2015	14	Goldeye/mooneye	LAR	0	0	0	76.6	0	38.3	19.1
2015	6/2/2015	14	Grass carp	YSL	0	639	319.5	0	0	0	159.8
2015	6/2/2015	14	Minnows group 2	PYSL	0	159.8	79.9	0	0	0	40
2015	6/2/2015	14	Silver/bighead carp	LAR	35309.5	0	17654.8	16081.8	0	8040.9	12847.8
2015	6/2/2015	14	Silver/bighead carp	PYSL	0	36105.6	18052.8	2220.8	15240.5	8730.6	13391.7
2015	6/2/2015	14	Silver/bighead carp	YSL	0	2236.6	1118.3	842.4	919	880.7	999.5
2015	6/2/2015	14	Unidentifiable fish	EGG	0	159.8	79.9	306.3	153.2	229.8	154.8
2015	6/2/2015	14	Unidentifiable fish	LAR	4154.1	1757.4	2955.8	1455	459.5	957.2	1956.5
2015	6/9/2015	15	Common carp	LAR	0	0	0	78.3	39.1	58.7	29.4
2015	6/9/2015	15	Common carp	PYSL	0	78.1	39	0	78.2	39.1	39.1
2015	6/9/2015	15	Freshwater drum	EGG	159.8	351.3	255.6	0	0	0	127.8
2015	6/9/2015	15	Freshwater drum	LAR	0	0	0	234.8	0	117.4	58.7



Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	6/9/2015	15	Freshwater drum	PYSL	239.7	78.1	158.9	0	117.3	58.6	108.8
2015	6/9/2015	15	Gizzard shad	PYSL	159.8	195.2	177.5	78.3	78.2	78.2	127.9
2015	6/9/2015	15	Goldeye	PYSL	0	0	0	78.3	0	39.1	19.6
2015	6/9/2015	15	Minnows	LAR	0	0	0	0	1369	684.5	342.2
2015	6/9/2015	15	Minnows	PYSL	998.9	624.5	811.7	0	0	0	405.9
2015	6/9/2015	15	Minnows	YSL	79.9	0	40	0	0	0	20
2015	6/9/2015	15	Shortnose gar	LAR	0	39	19.5	0	0	0	9.8
2015	6/9/2015	15	Silver/bighead carp	LAR	5873.4	10850.6	8362	12758.5	10756.6	11757.5	10059.8
2015	6/9/2015	15	Silver/bighead carp	PYSL	479.5	429.3	454.4	704.5	1994.9	1349.7	902.1
2015	6/9/2015	15	Silver/bighead carp	YSL	399.5	117.1	258.3	313.1	430.3	371.7	315
2015	6/9/2015	15	Unidentifiable fish	EGG	199.8	0	99.9	0	0	0	50
2015	6/9/2015	15	Unidentifiable fish	LAR	1318.5	1053.8	1186.2	1408.9	665	1037	1111.5
2015	6/16/2015	16	Common carp	JUV	0	38.9	19.4	0	79.3	39.6	29.5
2015	6/16/2015	16	Crappies	JUV	0	0	0	0	79.3	39.6	19.8
2015	6/16/2015	16	Freshwater drum	LAR	195.5	155.5	175.5	234.1	475.8	354.9	265.2
2015	6/16/2015	16	Freshwater drum	PYSL	117.3	0	58.6	0	0	0	29.3
2015	6/16/2015	16	Gizzard shad	LAR	469.3	0	234.7	0	79.3	39.6	137.2
2015	6/16/2015	16	Goldeye	JUV	39.1	0	19.6	0	0	0	9.8
2015	6/16/2015	16	Grass carp	YSL	0	116.6	58.3	0	0	0	29.1
2015	6/16/2015	16	Herrings-shads	LAR	0	311	155.5	546.2	317.2	431.7	293.6
2015	6/16/2015	16	Minnows	LAR	2737.5	1438.1	2087.8	702.3	1348	1025.2	1556.5
2015	6/16/2015	16	Silver/bighead carp	JUV	39.1	0	19.6	0	0	0	9.8

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m <sup>3</sup> )						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	6/16/2015	16	Silver/bighead carp	LAR	7586.9	8279.1	7933	3121.3	11735.7	7428.5	7680.8
2015	6/16/2015	16	Silver/bighead carp	PYSL	0	816.2	408.1	8739.7	0	4369.9	2389
2015	6/16/2015	16	Silver/bighead carp	YSL	664.8	1010.6	837.7	1482.6	1427.3	1454.9	1146.3
2015	6/16/2015	16	Suckers	LAR	0	0	0	234.1	0	117	58.5
2015	6/16/2015	16	Unidentifiable fish	EGG	0	38.9	19.4	0	475.8	237.9	128.7
2015	6/16/2015	16	Unidentifiable fish	LAR	312.9	194.3	253.6	0	0	0	126.8
2015	6/23/2015	17	Buffalofish	JUV	0	0	0	19.5	0	9.8	4.9
2015	6/23/2015	17	Common carp	JUV	39.1	0	19.6	0	19.3	9.7	14.6
2015	6/23/2015	17	Common carp	PYSL	0	0	0	39.1	0	19.6	9.8
2015	6/23/2015	17	Common carp	YSL	0	0	0	0	19.3	9.7	4.8
2015	6/23/2015	17	Freshwater drum	PYSL	97.8	266.5	182.2	293	116.1	204.6	193.3
2015	6/23/2015	17	Gizzard shad	LAR	0	228.4	114.2	0	0	0	57.1
2015	6/23/2015	17	Gizzard shad	PYSL	19.6	0	9.8	195.4	58	126.7	68.2
2015	6/23/2015	17	Minnows	PYSL	58.7	0	29.4	0	0	0	14.7
2015	6/23/2015	17	Silver/bighead carp	LAR	0	0	0	2832.7	0	1416.3	708.2
2015	6/23/2015	17	Silver/bighead carp	PYSL	5435	5576.9	5505.9	2109.9	4198.1	3154	4330
2015	6/23/2015	17	Unidentifiable fish	JUV	0	0	0	19.5	0	9.8	4.9
2015	6/23/2015	17	Unidentifiable fish	LAR	508.3	0	254.2	234.4	251.5	242.9	248.6
2015	6/23/2015	17	Unidentifiable fish	PYSL	0	437.8	218.9	0	0	0	109.5
2015	6/23/2015	17	White bass	JUV	19.6	0	9.8	0	0	0	4.9
2015	6/23/2015	17	White crappie	PYSL	0	0	0	19.5	0	9.8	4.9
2015	6/30/2015	18	Buffalofish	YSL	9.8	0	4.9	0	0	0	2.5

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	6/30/2015	18	Common carp	PYSL	9.8	0	4.9	0	0	0	2.5
2015	6/30/2015	18	Freshwater drum	JUV	0	0	0	9.8	0	4.9	2.5
2015	6/30/2015	18	Freshwater drum	PYSL	146.7	195.5	171.1	9.8	57.9	33.9	102.5
2015	6/30/2015	18	Gizzard shad	JUV	48.9	9.8	29.4	0	9.6	4.8	17.1
2015	6/30/2015	18	Gizzard shad	PYSL	97.8	166.2	132	0	9.6	4.8	68.4
2015	6/30/2015	18	Grass carp	PYSL	0	0	0	0	9.6	4.8	2.4
2015	6/30/2015	18	Silver carp	JUV	0	0	0	9.8	0	4.9	2.5
2015	6/30/2015	18	Silver/bighead carp	LAR	0	0	0	2124.4	0	1062.2	531.1
2015	6/30/2015	18	Silver/bighead carp	PYSL	2102.7	2013.7	2058.2	244.7	1939.6	1092.1	1575.2
2015	6/30/2015	18	Silver/bighead carp	YSL	0	48.9	24.4	68.5	86.8	77.7	51
2015	6/30/2015	18	Unidentifiable fish	LAR	156.5	303	229.8	479.7	395.6	437.6	333.7
2015	6/30/2015	18	White bass	PYSL	0	0	0	0	9.6	4.8	2.4
2015	7/7/2015	19	Carp suckers	PYSL	0	39.1	19.6	48.8	19.5	34.1	26.9
2015	7/7/2015	19	Common carp	JUV	0	9.8	4.9	0	9.7	4.8	4.9
2015	7/7/2015	19	Freshwater drum	JUV	0	0	0	0	9.7	4.8	2.4
2015	7/7/2015	19	Freshwater drum	PYSL	156.4	107.6	132	117	38.9	78	105
2015	7/7/2015	19	Gizzard shad	JUV	127.1	9.8	68.5	19.5	126.6	73	70.8
2015	7/7/2015	19	Gizzard shad	PYSL	166.2	58.7	112.4	97.5	68.2	82.8	97.7
2015	7/7/2015	19	Silver/bighead carp	JUV	9.8	9.8	9.8	0	19.5	9.8	9.8
2015	7/7/2015	19	Silver/bighead carp	LAR	195.5	0	97.8	0	0	0	48.9
2015	7/7/2015	19	Silver/bighead carp	PYSL	0	156.5	78.2	243.8	262.9	253.3	165.8
2015	7/7/2015	19	Unidentifiable fish	LAR	0	107.6	53.8	19.5	0	9.8	31.8

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
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					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	7/7/2015	19	White bass	PYSL	9.8	0	4.9	0	0	0	2.5
2015	7/14/2015	20	Carp suckers	PYSL	0	0	0	0	9.8	4.9	2.5
2015	7/14/2015	20	Catfishes	PYSL	0	0	0	9.7	0	4.8	2.4
2015	7/14/2015	20	Channel catfish	JUV	0	9.8	4.9	0	0	0	2.5
2015	7/14/2015	20	Common carp	PYSL	0	19.5	9.8	9.7	0	4.8	7.3
2015	7/14/2015	20	Freshwater drum	LAR	0	0	0	0	9.8	4.9	2.5
2015	7/14/2015	20	Freshwater drum	PYSL	107.6	97.7	102.7	9.7	0	4.8	53.8
2015	7/14/2015	20	Gizzard shad	JUV	29.3	9.8	19.6	19.4	48.9	34.1	26.9
2015	7/14/2015	20	Gizzard shad	PYSL	19.6	19.5	19.6	38.7	58.6	48.7	34.1
2015	7/14/2015	20	Silver/bighead carp	LAR	0	0	0	0	166.2	83.1	41.5
2015	7/14/2015	20	Silver/bighead carp	PYSL	215.1	205.2	210.1	77.5	29.3	53.4	131.8
2015	7/14/2015	20	Unidentifiable fish	LAR	0	29.3	14.7	58.1	0	29.1	21.9
2015	7/14/2015	20	Unidentifiable fish	PYSL	9.8	0	4.9	0	48.9	24.4	14.7
2015	7/21/2015	21	Carp suckers	PYSL	9.8	0	4.9	29.2	0	14.6	9.8
2015	7/21/2015	21	Channel catfish	LAR	9.8	0	4.9	0	0	0	2.5
2015	7/21/2015	21	Freshwater drum	LAR	0	0	0	97.2	0	48.6	24.3
2015	7/21/2015	21	Freshwater drum	PYSL	97.7	107.4	102.6	0	77.9	39	70.8
2015	7/21/2015	21	Gizzard shad	JUV	0	9.8	4.9	9.7	0	4.8	4.9
2015	7/21/2015	21	Gizzard shad	PYSL	9.8	9.8	9.8	9.7	19.5	14.6	12.2
2015	7/21/2015	21	Grass carp	PYSL	9.8	0	4.9	0	0	0	2.5
2015	7/21/2015	21	Minnows group 5	PYSL	0	0	0	9.7	0	4.8	2.4
2015	7/21/2015	21	Silver/bighead carp	JUV	0	0	0	9.7	0	4.8	2.4

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
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2015	7/21/2015	21	Silver/bighead carp	PYSL	927.8	868.9	898.3	3568.7	4437.9	4003.3	2450.8
2015	7/21/2015	21	Silver/bighead carp	YSL	0	0	0	48.6	58.4	53.5	26.8
2015	7/21/2015	21	Unidentifiable fish	LAR	0	0	0	0	214.1	107	53.5
2015	7/21/2015	21	Unidentifiable fish	PYSL	68.4	0	34.2	0	0	0	17.1
2015	7/28/2015	22	Blue catfish	PYSL	0	0	0	0	9.8	4.9	2.5
2015	7/28/2015	22	Carp sucker/buffalofish	PYSL	9.8	0	4.9	0	0	0	2.5
2015	7/28/2015	22	Freshwater drum	LAR	0	0	0	28.9	9.8	19.4	9.7
2015	7/28/2015	22	Freshwater drum	PYSL	19.6	78	48.8	0	0	0	24.4
2015	7/28/2015	22	Gizzard shad	JUV	0	9.8	4.9	0	0	0	2.5
2015	7/28/2015	22	Gizzard shad	PYSL	19.6	0	9.8	19.2	0	9.6	9.7
2015	7/28/2015	22	Silver/bighead carp	LAR	0	0	0	519.6	234.3	377	188.5
2015	7/28/2015	22	Silver/bighead carp	PYSL	676.5	633.8	655.1	144.3	58.6	101.5	378.3
2015	7/28/2015	22	Sunfishes	PYSL	9.8	0	4.9	0	0	0	2.5
2015	7/28/2015	22	Unidentifiable fish	LAR	78.4	0	39.2	0	0	0	19.6
2015	7/28/2015	22	Unidentifiable fish	PYSL	0	58.5	29.2	0	0	0	14.6
2015	8/4/2015	23	Channel catfish	JUV	9.8	0	4.9	0	9.8	4.9	4.9
2015	8/4/2015	23	Channel catfish	PYSL	0	0	0	9.8	0	4.9	2.5
2015	8/4/2015	23	Freshwater drum	EGG	0	9.8	4.9	9.8	0	4.9	4.9
2015	8/4/2015	23	Freshwater drum	PYSL	0	0	0	29.3	9.8	19.6	9.8
2015	8/4/2015	23	Grass carp	PYSL	0	0	0	48.8	68.4	58.6	29.3
2015	8/4/2015	23	Minnows group 2	PYSL	0	0	0	39.1	9.8	24.5	12.2
2015	8/4/2015	23	Minnows group 6	PYSL	0	0	0	0	9.8	4.9	2.5

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	8/4/2015	23	Silver/bighead carp	PYSL	459.5	517.6	488.6	635	459.5	547.2	517.9
2015	8/4/2015	23	Unidentifiable fish	LAR	0	0	0	39.1	0	19.6	9.8
2015	8/4/2015	23	Unidentifiable fish	PYSL	0	48.8	24.4	0	19.6	9.8	17.1
2015	8/11/2015	24	Carp sucker/buffalofish	PYSL	29	19.5	24.2	18.7	0	9.3	16.8
2015	8/11/2015	24	Carp suckers	PYSL	19.4	0	9.7	9.4	9.4	9.4	9.6
2015	8/11/2015	24	Channel catfish	PYSL	0	0	0	0	9.4	4.7	2.4
2015	8/11/2015	24	Freshwater drum	EGG	0	9.8	4.9	18.7	0	9.3	7.1
2015	8/11/2015	24	Freshwater drum	PYSL	38.7	9.8	24.2	9.4	18.8	14.1	19.2
2015	8/11/2015	24	Minnows	LAR	0	0	0	0	37.6	18.8	9.4
2015	8/11/2015	24	Minnows	PYSL	0	0	0	9.4	0	4.7	2.4
2015	8/11/2015	24	Minnows group 2	PYSL	0	0	0	0	9.4	4.7	2.4
2015	8/11/2015	24	Silver/bighead carp	PYSL	0	48.9	24.4	0	56.4	28.2	26.3
2015	8/11/2015	24	Sunfishes	JUV	9.7	0	4.8	0	0	0	2.4
2015	8/11/2015	24	Sunfishes	PYSL	0	19.5	9.8	37.4	0	18.7	14.2
2015	8/11/2015	24	Unidentifiable fish	LAR	9.7	19.5	14.6	28.1	0	14.1	14.3
2015	8/18/2015	25	Carp sucker/buffalofish	LAR	0	39.2	19.6	0	0	0	9.8
2015	8/18/2015	25	Carp sucker/buffalofish	PYSL	29.3	19.6	24.5	9.8	49.1	29.5	27
2015	8/18/2015	25	Freshwater drum	EGG	0	9.8	4.9	9.8	0	4.9	4.9
2015	8/18/2015	25	Freshwater drum	PYSL	0	9.8	4.9	0	0	0	2.5
2015	8/18/2015	25	Grass carp	PYSL	58.5	137.2	97.8	39.1	49.1	44.1	71
2015	8/18/2015	25	Minnows	LAR	0	0	0	19.6	9.8	14.7	7.4
2015	8/18/2015	25	Minnows	PYSL	9.8	0	4.9	0	0	0	2.5

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2015	8/18/2015	25	Silver/bighead carp	PYSL	156	137.2	146.6	244.5	304.5	274.5	210.6
2015	8/18/2015	25	Sunfishes	PYSL	0	49	24.5	0	0	0	12.2
2015	8/25/2015	26	Carp sucker/buffalofish	PYSL	0	37.2	18.6	39.1	0	19.6	19.1
2015	8/25/2015	26	Carp suckers	PYSL	0	0	0	0	19.5	9.8	4.9
2015	8/25/2015	26	Freshwater drum	EGG	9.7	9.3	9.5	9.8	9.8	9.8	9.7
2015	8/25/2015	26	Freshwater drum	PYSL	0	27.9	13.9	0	0	0	7
2015	8/25/2015	26	Grass carp	PYSL	9.7	0	4.8	0	0	0	2.4
2015	8/25/2015	26	Minnows	LAR	0	18.6	9.3	9.8	0	4.9	7.1
2015	8/25/2015	26	Silver/bighead carp	PYSL	57.9	0	28.9	9.8	0	4.9	16.9
2015	9/1/2015	27	Freshwater drum	EGG	19.5	29.5	24.5	0	0	0	12.2
2015	9/1/2015	27	Freshwater drum	PYSL	9.8	0	4.9	0	0	0	2.5
2015	9/1/2015	27	Silver/bighead carp	LAR	0	9.8	4.9	0	0	0	2.5
2015	9/1/2015	27	Silver/bighead carp	PYSL	39.1	9.8	24.5	9.6	29.1	19.4	21.9
2015	9/8/2015	28	Freshwater drum	EGG	0	0	0	0	9.8	4.9	2.5
2015	9/8/2015	28	Freshwater drum	PYSL	0	0	0	9.8	9.8	9.8	4.9
2015	9/8/2015	28	Unidentifiable fish	PYSL	0	9.7	4.8	0	0	0	2.4
2015	9/15/2015	29	Freshwater drum	EGG	9.8	0	4.9	0	0	0	2.5
2015	9/15/2015	29	Grass carp	PYSL	0	0	0	47.9	0	23.9	12
2015	9/15/2015	29	Minnows	PYSL	0	58.7	29.4	38.3	28	33.1	31.2
2015	9/15/2015	29	Silver/bighead carp	LAR	48.9	0	24.4	0	0	0	12.2
2015	9/15/2015	29	Silver/bighead carp	PYSL	9.8	0	4.9	9.6	0	4.8	4.8
2015	9/22/2015	30	Freshwater drum	PYSL	0	0	0	9.7	9.8	9.8	4.9

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
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2015	9/22/2015	30	Sunfishes	PYSL	9.7	0	4.8	0	0	0	2.4
2015	9/22/2015	30	Unidentifiable fish	PYSL	0	0	0	0	9.8	4.9	2.5
2016	3/1/2016	31	No fish collected	--	--	--	--	--	--	--	--
2016	3/8/2016	32	No fish collected	--	--	--	--	--	--	--	--
2016	3/15/2016	33	No fish collected	--	--	--	--	--	--	--	--
2016	3/22/2016	34	Logperch	PYSL	0	0	0	9.8	0	4.9	2.5
2016	3/29/2016	35	No fish collected	--	--	--	--	--	--	--	--
2016	4/5/2016	36	No fish collected	--	--	--	--	--	--	--	--
2016	4/12/2016	37	Minnows group 3	PYSL	0	0	0	9.7	0	4.8	2.4
2016	4/19/2016	38	Carp sucker/buffalofish	PYSL	0	29.3	14.7	0	0	0	7.3
2016	4/19/2016	38	Carp sucker/buffalofish	YSL	0	0	0	19.5	0	9.8	4.9
2016	4/19/2016	38	Carp suckers	PYSL	29.2	0	14.6	0	9.7	4.8	9.7
2016	4/19/2016	38	Darter (Percina)	YSL	0	9.8	4.9	0	0	0	2.5
2016	4/19/2016	38	Redhorse suckers	YSL	0	0	0	0	9.7	4.8	2.4
2016	4/19/2016	38	Redhorses/white sucker	PYSL	0	0	0	0	9.7	4.8	2.4
2016	4/19/2016	38	Unidentifiable fish	LAR	0	0	0	9.8	0	4.9	2.5
2016	4/19/2016	38	Walleye/sauger	PYSL	0	9.8	4.9	9.8	0	4.9	4.9
2016	4/19/2016	38	Walleye/sauger	YSL	9.7	0	4.8	0	0	0	2.4
2016	4/26/2016	39	Blue sucker	LAR	0	29.3	14.7	0	0	0	7.3
2016	4/26/2016	39	Blue sucker	PYSL	0	0	0	9.6	0	4.8	2.4
2016	4/26/2016	39	Blue sucker	YSL	9.7	0	4.8	0	0	0	2.4
2016	4/26/2016	39	Buffalofish	PYSL	29.2	0	14.6	0	0	0	7.3



Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
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2016	4/26/2016	39	Carp sucker/buffalofish	PYSL	19.5	362	190.8	287.5	222.7	255.1	222.9
2016	4/26/2016	39	Carp suckers	PYSL	58.5	0	29.2	0	0	0	14.6
2016	4/26/2016	39	Carp suckers	YSL	29.2	0	14.6	0	0	0	7.3
2016	4/26/2016	39	Common carp	YSL	0	0	0	9.6	0	4.8	2.4
2016	4/26/2016	39	Darter (Etheostoma)	PYSL	0	0	0	0	9.7	4.8	2.4
2016	4/26/2016	39	Darter (Etheostoma)	YSL	0	0	0	9.6	0	4.8	2.4
2016	4/26/2016	39	Minnows group 4	PYSL	0	0	0	9.6	0	4.8	2.4
2016	4/26/2016	39	Minnows group 6	PYSL	0	0	0	9.6	0	4.8	2.4
2016	4/26/2016	39	Redhorse suckers	PYSL	0	0	0	28.7	19.4	24	12
2016	4/26/2016	39	Unidentifiable fish	LAR	0	29.3	14.7	19.2	19.4	19.3	17
2016	4/26/2016	39	Walleye/sauger	PYSL	0	0	0	0	9.7	4.8	2.4
2016	5/3/2016	40	Blue sucker	LAR	48.9	0	24.4	0	0	0	12.2
2016	5/3/2016	40	Blue sucker	YSL	19.5	0	9.8	9.6	0	4.8	7.3
2016	5/3/2016	40	Buffalofish	PYSL	0	0	0	67.3	126.3	96.8	48.4
2016	5/3/2016	40	Buffalofish	YSL	215	146	180.5	0	0	0	90.2
2016	5/3/2016	40	Carp sucker/buffalofish	LAR	273.6	496.6	385.1	269	223.4	246.2	315.7
2016	5/3/2016	40	Carp suckers	PYSL	0	0	0	9.6	0	4.8	2.4
2016	5/3/2016	40	Carp suckers	YSL	68.4	87.6	78	48	48.6	48.3	63.1
2016	5/3/2016	40	Freshwater drum	EGG	0	0	0	86.5	0	43.2	21.6
2016	5/3/2016	40	Gizzard shad	LAR	0	19.5	9.8	0	0	0	4.9
2016	5/3/2016	40	Goldeye	LAR	0	0	0	0	9.7	4.8	2.4
2016	5/3/2016	40	Goldeye	YSL	68.4	58.4	63.4	57.6	0	28.8	46.1

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2016	5/3/2016	40	Goldeye/mooneye	LAR	58.6	0	29.3	86.5	0	43.2	36.3
2016	5/3/2016	40	Goldeye/mooneye	YSL	0	126.6	63.3	0	0	0	31.6
2016	5/3/2016	40	Logperch	YSL	9.8	0	4.9	0	0	0	2.5
2016	5/3/2016	40	Minnows	LAR	0	0	0	0	48.6	24.3	12.2
2016	5/3/2016	40	Minnows group 3	PYSL	19.5	0	9.8	0	0	0	4.9
2016	5/3/2016	40	Minnows group 6	LAR	0	0	0	0	19.4	9.7	4.8
2016	5/3/2016	40	Mooneye	LAR	0	0	0	0	19.4	9.7	4.8
2016	5/3/2016	40	Mooneye	YSL	87.9	0	44	0	0	0	22
2016	5/3/2016	40	Paddlefish	LAR	0	0	0	9.6	0	4.8	2.4
2016	5/3/2016	40	Unidentifiable fish	EGG	19.5	9.7	14.6	76.9	77.7	77.3	46
2016	5/3/2016	40	Unidentifiable fish	LAR	19.5	0	9.8	19.2	0	9.6	9.7
2016	5/3/2016	40	Walleye	PYSL	0	9.7	4.8	0	0	0	2.4
2016	5/3/2016	40	Walleye/sauger	YSL	0	0	0	9.6	0	4.8	2.4
2016	5/3/2016	40	White sucker	LAR	0	19.5	9.8	57.6	38.8	48.2	29
2016	5/3/2016	40	White sucker	PYSL	0	0	0	0	19.4	9.7	4.8
2016	5/10/2016	41	Blue sucker	PYSL	0	0	0	18.7	19.7	19.2	9.6
2016	5/10/2016	41	Blue sucker	YSL	29.2	39.1	34.1	0	0	0	17.1
2016	5/10/2016	41	Buffalofish	PYSL	9.7	19.6	14.7	18.7	0	9.3	12
2016	5/10/2016	41	Buffalofish	YSL	48.6	39.1	43.9	65.5	88.6	77	60.5
2016	5/10/2016	41	Carp sucker/buffalofish	LAR	0	244.6	122.3	439.5	600.5	520	321.1
2016	5/10/2016	41	Carp sucker/buffalofish	YSL	408.4	0	204.2	0	0	0	102.1
2016	5/10/2016	41	Carp suckers	PYSL	58.3	0	29.1	0	0	0	14.6

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2016	5/10/2016	41	Carp suckers	YSL	107	88	97.5	102.9	187	144.9	121.2
2016	5/10/2016	41	Common carp	PYSL	0	0	0	9.4	0	4.7	2.4
2016	5/10/2016	41	Crappies	PYSL	9.7	0	4.8	0	0	0	2.4
2016	5/10/2016	41	Darter (Etheostoma)	PYSL	9.7	0	4.8	0	0	0	2.4
2016	5/10/2016	41	Freshwater drum	EGG	19.4	0	9.7	0	0	0	4.8
2016	5/10/2016	41	Gizzard shad	LAR	19.4	0	9.7	112.2	0	56.1	32.9
2016	5/10/2016	41	Gizzard shad	PYSL	19.4	29.3	24.4	0	0	0	12.2
2016	5/10/2016	41	Goldeye/mooneye	LAR	9.7	0	4.8	0	0	0	2.4
2016	5/10/2016	41	Herrings-shads	LAR	0	0	0	0	98.4	49.2	24.6
2016	5/10/2016	41	Silver/bighead carp	YSL	0	0	0	0	19.7	9.8	4.9
2016	5/10/2016	41	Unidentifiable fish	EGG	19.4	39.1	29.2	93.5	108.3	100.9	65.1
2016	5/10/2016	41	Walleye/sauger	PYSL	0	0	0	0	9.8	4.9	2.5
2016	5/17/2016	42	Buffalofish	YSL	0	0	0	0	313.1	156.6	78.3
2016	5/17/2016	42	Common carp	YSL	0	310	155	0	0	0	77.5
2016	5/17/2016	42	Gizzard shad	LAR	0	0	0	156	0	78	39
2016	5/17/2016	42	Gizzard shad	PYSL	77.6	0	38.8	0	0	0	19.4
2016	5/17/2016	42	Goldeye	YSL	0	155	77.5	156	313.1	234.6	156
2016	5/17/2016	42	Goldeye/mooneye	PYSL	155.2	0	77.6	0	0	0	38.8
2016	5/17/2016	42	Minnows	LAR	0	4339.6	2169.8	13885.3	17064.2	15474.8	8822.3
2016	5/17/2016	42	Mooneye	YSL	0	0	0	156	0	78	39
2016	5/17/2016	42	Silver/bighead carp	LAR	18315.1	0	9157.5	11545.1	0	5772.6	7465
2016	5/17/2016	42	Silver/bighead carp	YSL	2483.4	29602.1	16042.8	4992.5	20977.9	12985.2	14514

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2016	5/17/2016	42	Suckers	LAR	0	0	0	156	0	78	39
2016	5/17/2016	42	Unidentifiable fish	EGG	0	155	77.5	156	0	78	77.8
2016	5/17/2016	42	Unidentifiable fish	LAR	543.2	0	271.6	0	0	0	135.8
2016	5/24/2016	43	Blue sucker	YSL	0	0	0	9.8	0	4.9	2.5
2016	5/24/2016	43	Buffalofish	PYSL	0	29.3	14.7	0	29.2	14.6	14.6
2016	5/24/2016	43	Buffalofish	YSL	0	9.8	4.9	0	48.7	24.4	14.6
2016	5/24/2016	43	Carp sucker/buffalofish	LAR	0	0	0	0	19.5	9.8	4.9
2016	5/24/2016	43	Carp sucker/buffalofish	PYSL	0	0	0	88.2	0	44.1	22.1
2016	5/24/2016	43	Carp suckers	LAR	9.7	0	4.8	0	0	0	2.4
2016	5/24/2016	43	Common carp	LAR	0	68.3	34.1	9.8	0	4.9	19.5
2016	5/24/2016	43	Common carp	PYSL	0	0	0	0	39	19.5	9.8
2016	5/24/2016	43	Gizzard shad	LAR	9.7	29.3	19.5	0	9.7	4.8	12.2
2016	5/24/2016	43	Gizzard shad	PYSL	19.5	0	9.8	0	19.5	9.8	9.8
2016	5/24/2016	43	Goldeye	PYSL	0	9.8	4.9	0	0	0	2.5
2016	5/24/2016	43	Goldeye	YSL	38.9	29.3	34.1	19.6	9.7	14.7	24.4
2016	5/24/2016	43	Logperch	LAR	0	0	0	0	9.7	4.8	2.4
2016	5/24/2016	43	Minnows	LAR	19.5	0	9.8	9.8	0	4.9	7.3
2016	5/24/2016	43	Mooneye	YSL	9.7	0	4.8	0	0	0	2.4
2016	5/24/2016	43	Silver/bighead carp	LAR	48.7	0	24.4	0	0	0	12.2
2016	5/24/2016	43	Unidentifiable fish	EGG	29.2	341.7	185.4	529.4	409.1	469.2	327.4
2016	5/24/2016	43	Unidentifiable fish	LAR	9.7	19.5	14.6	49	0	24.5	19.6
2016	5/31/2016	44	Common carp	PYSL	0	0	0	0	469.4	234.7	117.3

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2016	5/31/2016	44	Gizzard shad	PYSL	0	0	0	0	156.5	78.2	39.1
2016	5/31/2016	44	Goldeye/mooneye	LAR	0	935.6	467.8	0	156.5	78.2	273
2016	5/31/2016	44	Grass carp	LAR	0	623.8	311.9	0	0	0	155.9
2016	5/31/2016	44	Grass carp	PYSL	0	0	0	0	1095.4	547.7	273.9
2016	5/31/2016	44	Grass carp	YSL	3421.6	1871.3	2646.4	312.9	0	156.4	1401.5
2016	5/31/2016	44	Silver/bighead carp	LAR	0	9980.1	4990.1	44742.3	3442.6	24092.5	14541.2
2016	5/31/2016	44	Silver/bighead carp	YSL	64077	65182.8	64629.9	13766.9	46631.7	30199.3	47414.6
2016	5/31/2016	44	Unidentifiable fish	EGG	1244.2	1871.3	1557.8	0	313	156.5	857.1
2016	5/31/2016	44	White bass	YSL	311.1	0	155.6	0	0	0	77.8
2016	6/7/2016	45	Buffalofish	YSL	0	0	0	0	19.6	9.8	4.9
2016	6/7/2016	45	Carp suckers	LAR	0	0	0	0	19.6	9.8	4.9
2016	6/7/2016	45	Carp suckers	YSL	233.6	78.3	155.9	0	0	0	78
2016	6/7/2016	45	Common carp	JUV	0	39.1	19.6	0	0	0	9.8
2016	6/7/2016	45	Freshwater drum	LAR	155.7	0	77.8	0	0	0	38.9
2016	6/7/2016	45	Freshwater drum	YSL	934.3	1487	1210.7	765.7	294	529.9	870.2
2016	6/7/2016	45	Gizzard shad	PYSL	194.6	0	97.3	76.6	78.4	77.5	87.4
2016	6/7/2016	45	Grass carp	YSL	38.9	430.4	234.6	191.4	98	144.7	189.7
2016	6/7/2016	45	Minnows group 2	LAR	38.9	0	19.4	0	0	0	9.7
2016	6/7/2016	45	Minnows group 2	YSL	0	78.3	39.1	38.3	0	19.1	29.1
2016	6/7/2016	45	Silver/bighead carp	LAR	6189.7	0	3094.8	4326.5	1567.8	2947.2	3021
2016	6/7/2016	45	Silver/bighead carp	PYSL	0	391.3	195.7	38.3	0	19.1	107.4
2016	6/7/2016	45	Silver/bighead carp	YSL	0	7630.5	3815.2	2756.7	2077.3	2417	3116.1

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2016	6/7/2016	45	Unidentifiable fish	EGG	77.9	313	195.4	76.6	39.2	57.9	126.7
2016	6/7/2016	45	Unidentifiable fish	LAR	350.4	0	175.2	0	0	0	87.6
2016	6/14/2016	46	Carp sucker/buffalo fish	LAR	0	204.8	102.4	525.3	214.8	370	236.2
2016	6/14/2016	46	Carp sucker/buffalo fish	PYSL	352	0	176	0	0	0	88
2016	6/14/2016	46	Carp sucker/buffalo fish	YSL	123.7	253.5	188.6	0	0	0	94.3
2016	6/14/2016	46	Carp suckers	LAR	0	29.3	14.7	0	0	0	7.3
2016	6/14/2016	46	Carp suckers	YSL	47.6	0	23.8	38.9	0	19.4	21.6
2016	6/14/2016	46	Crappies	PYSL	9.5	0	4.8	0	0	0	2.4
2016	6/14/2016	46	Freshwater drum	LAR	0	0	0	0	58.6	29.3	14.7
2016	6/14/2016	46	Freshwater drum	PYSL	656.5	224.3	440.4	107	126.9	117	278.7
2016	6/14/2016	46	Freshwater drum	YSL	76.1	507.1	291.6	515.6	380.8	448.2	369.9
2016	6/14/2016	46	Gizzard shad	PYSL	85.6	68.3	76.9	68.1	0	34	55.5
2016	6/14/2016	46	Grass carp	PYSL	0	0	0	9.7	0	4.8	2.4
2016	6/14/2016	46	Grass carp	YSL	19	0	9.5	0	19.5	9.8	9.6
2016	6/14/2016	46	Minnows	LAR	28.5	0	14.2	0	0	0	7.1
2016	6/14/2016	46	Minnows group 2	YSL	0	0	0	9.7	0	4.8	2.4
2016	6/14/2016	46	Minnows group 6	PYSL	19	0	9.5	0	0	0	4.8
2016	6/14/2016	46	Mooneye	PYSL	0	9.8	4.9	0	0	0	2.5
2016	6/14/2016	46	Silver/bighead carp	LAR	0	321.8	160.9	0	722.5	361.2	261.1
2016	6/14/2016	46	Silver/bighead carp	PYSL	285.4	0	142.7	330.7	0	165.3	154
2016	6/14/2016	46	Sunfishes	PYSL	0	19.5	9.8	0	0	0	4.9
2016	6/14/2016	46	Sunfishes (Lepomis)	PYSL	0	0	0	9.7	0	4.8	2.4

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	6/14/2016	46	Unidentifiable fish	EGG	28.5	165.8	97.2	29.2	0	14.6	55.9
2016	6/14/2016	46	Unidentifiable fish	PYSL	0	0	0	9.7	0	4.8	2.4
2016	6/21/2016	47	Carp sucker/buffalo fish	LAR	0	63.1	31.6	0	0	0	15.8
2016	6/21/2016	47	Carp sucker/buffalo fish	PYSL	0	0	0	47.7	312.8	180.2	90.1
2016	6/21/2016	47	Freshwater drum	LAR	97.6	0	48.8	114.4	48.9	81.7	65.2
2016	6/21/2016	47	Freshwater drum	PYSL	0	153.2	76.6	0	0	0	38.3
2016	6/21/2016	47	Gizzard shad	LAR	9.8	18	13.9	0	0	0	7
2016	6/21/2016	47	Gizzard shad	PYSL	0	0	0	9.5	0	4.8	2.4
2016	6/21/2016	47	Grass carp	LAR	9.8	0	4.9	0	0	0	2.5
2016	6/21/2016	47	Silver/bighead carp	LAR	390.2	243.3	316.8	152.5	0	76.2	196.5
2016	6/21/2016	47	Silver/bighead carp	PYSL	29.3	0	14.7	9.5	29.3	19.4	17
2016	6/21/2016	47	Sunfishes	PYSL	0	9	4.5	0	0	0	2.2
2016	6/21/2016	47	Unidentifiable fish	EGG	9.8	9	9.4	9.5	19.5	14.5	11.9
2016	6/28/2016	48	Carp sucker/buffalo fish	PYSL	0	9.9	5	0	0	0	2.5
2016	6/28/2016	48	Carp sucker/buffalo fish	YSL	0	69.5	34.8	0	19.5	9.8	22.2
2016	6/28/2016	48	Freshwater drum	YSL	39.1	89.3	64.2	9.7	48.8	29.2	46.7
2016	6/28/2016	48	Gizzard shad	PYSL	0	0	0	9.7	0	4.8	2.4
2016	6/28/2016	48	Grass carp	YSL	29.3	69.5	49.4	78	165.8	121.9	85.7
2016	6/28/2016	48	Silver/bighead carp	LAR	713.3	536	624.6	613.9	507.2	560.5	592.6
2016	6/28/2016	48	Silver/bighead carp	PYSL	19.5	99.3	59.4	68.2	224.3	146.2	102.8
2016	6/28/2016	48	Silver/bighead carp	YSL	87.9	129	108.5	204.6	604.7	404.7	256.6
2016	6/28/2016	48	Unidentifiable fish	EGG	0	0	0	29.2	9.8	19.5	9.8

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	6/28/2016	48	Unidentifiable fish	LAR	19.5	79.4	49.5	9.7	48.8	29.2	39.4
2016	7/5/2016	49	Blue catfish	LAR	19.6	0	9.8	0	0	0	4.9
2016	7/5/2016	49	Blue catfish	PYSL	0	0	0	0	9.7	4.8	2.4
2016	7/5/2016	49	Blue catfish	YSL	0	0	0	0	9.7	4.8	2.4
2016	7/5/2016	49	Carp suckers	PYSL	273.8	0	136.9	39	19.5	29.2	83.1
2016	7/5/2016	49	Carp suckers	YSL	0	39.1	19.6	0	0	0	9.8
2016	7/5/2016	49	Freshwater drum	LAR	156.5	136.9	146.7	0	0	0	73.3
2016	7/5/2016	49	Freshwater drum	YSL	0	0	0	253.7	194.7	224.2	112.1
2016	7/5/2016	49	Gizzard shad	PYSL	19.6	0	9.8	0	0	0	4.9
2016	7/5/2016	49	Grass carp	LAR	0	39.1	19.6	0	0	0	9.8
2016	7/5/2016	49	Grass carp	YSL	352	0	176	0	0	0	88
2016	7/5/2016	49	Minnows group 2	LAR	39.1	0	19.6	0	0	0	9.8
2016	7/5/2016	49	Silver/bighead carp	LAR	5671.4	0	2835.7	0	0	0	1417.8
2016	7/5/2016	49	Silver/bighead carp	PYSL	195.6	215.1	205.3	117.1	48.7	82.9	144.1
2016	7/5/2016	49	Silver/bighead carp	YSL	0	4537.3	2268.7	3590.6	2745.3	3167.9	2718.3
2016	7/5/2016	49	Sunfishes (Lepomis)	JUV	0	0	0	19.5	0	9.8	4.9
2016	7/5/2016	49	Unidentifiable fish	EGG	176	39.1	107.5	39	0	19.5	63.5
2016	7/12/2016	50	Carp sucker/buffalofish	YSL	39.1	48.9	44	19.7	0	9.8	26.9
2016	7/12/2016	50	Carp suckers	YSL	29.3	0	14.7	0	99	49.5	32.1
2016	7/12/2016	50	Channel catfish	JUV	0	0	0	0	9.9	5	2.5
2016	7/12/2016	50	Common carp	PYSL	0	0	0	19.7	9.9	14.8	7.4
2016	7/12/2016	50	Freshwater drum	EGG	9.8	9.8	9.8	0	19.8	9.9	9.9



Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	7/12/2016	50	Freshwater drum	PYSL	39.1	107.5	73.3	59.2	79.2	69.2	71.2
2016	7/12/2016	50	Freshwater drum	YSL	9.8	0	4.9	9.9	9.9	9.9	7.4
2016	7/12/2016	50	Gizzard shad	PYSL	0	0	0	19.7	0	9.8	4.9
2016	7/12/2016	50	Grass carp	YSL	39.1	19.6	29.4	19.7	29.7	24.7	27
2016	7/12/2016	50	Minnows	LAR	9.8	0	4.9	0	0	0	2.5
2016	7/12/2016	50	Minnows group 2	YSL	0	9.8	4.9	0	0	0	2.5
2016	7/12/2016	50	Silver/bighead carp	LAR	0	48.9	24.4	0	0	0	12.2
2016	7/12/2016	50	Silver/bighead carp	PYSL	156.5	0	78.2	19.7	0	9.8	44
2016	7/12/2016	50	Silver/bighead carp	YSL	0	0	0	0	19.8	9.9	5
2016	7/19/2016	51	Carp sucker/buffalofish	YSL	0	0	0	254.9	0	127.5	63.7
2016	7/19/2016	51	Carp suckers	YSL	107.6	19.6	63.6	0	166.8	83.4	73.5
2016	7/19/2016	51	Catfish (Ictalurus)	JUV	0	0	0	19.6	0	9.8	4.9
2016	7/19/2016	51	Freshwater drum	EGG	19.6	0	9.8	0	0	0	4.9
2016	7/19/2016	51	Freshwater drum	PYSL	68.5	58.7	63.6	78.4	166.8	122.6	93.1
2016	7/19/2016	51	Gizzard shad	PYSL	39.1	0	19.6	9.8	39.2	24.5	22
2016	7/19/2016	51	Grass carp	LAR	9.8	0	4.9	0	0	0	2.5
2016	7/19/2016	51	Grass carp	YSL	0	39.1	19.6	19.6	39.2	29.4	24.5
2016	7/19/2016	51	Minnows	LAR	0	0	0	19.6	0	9.8	4.9
2016	7/19/2016	51	Minnows	PYSL	0	0	0	19.6	0	9.8	4.9
2016	7/19/2016	51	Minnows group 2	YSL	9.8	0	4.9	19.6	19.6	19.6	12.2
2016	7/19/2016	51	Minnows group 4	PYSL	0	0	0	0	9.8	4.9	2.5
2016	7/19/2016	51	Silver/bighead carp	LAR	48.9	19.6	34.2	88.2	0	44.1	39.2

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	7/19/2016	51	Silver/bighead carp	PYSL	137	68.5	102.8	0	98.1	49	75.9
2016	7/19/2016	51	Sunfishes (Lepomis)	PYSL	9.8	9.8	9.8	0	58.9	29.4	19.6
2016	7/26/2016	52	Carp sucker/buffalofish	YSL	39.6	39.2	39.4	38.4	67.8	53.1	46.2
2016	7/26/2016	52	Catfishes	YSL	0	0	0	9.6	0	4.8	2.4
2016	7/26/2016	52	Freshwater drum	JUV	0	0	0	0	9.7	4.8	2.4
2016	7/26/2016	52	Freshwater drum	LAR	0	9.8	4.9	0	0	0	2.5
2016	7/26/2016	52	Freshwater drum	YSL	29.7	0	14.8	28.8	38.7	33.8	24.3
2016	7/26/2016	52	Gizzard shad	JUV	0	0	0	19.2	29	24.1	12.1
2016	7/26/2016	52	Grass carp	YSL	257.4	166.8	212.1	76.9	87.1	82	147.1
2016	7/26/2016	52	Minnows group 2	PYSL	0	0	0	0	9.7	4.8	2.4
2016	7/26/2016	52	Silver/bighead carp	LAR	257.4	245.2	251.3	240.3	232.3	236.3	243.8
2016	7/26/2016	52	Silver/bighead carp	PYSL	59.4	49	54.2	0	0	0	27.1
2016	7/26/2016	52	Silver/bighead carp	YSL	49.5	78.5	64	0	77.4	38.7	51.4
2016	7/26/2016	52	Sunfishes (Lepomis)	PYSL	0	9.8	4.9	0	0	0	2.5
2016	7/26/2016	52	Unidentifiable fish	EGG	0	0	0	9.6	9.7	9.6	4.8
2016	8/2/2016	53	Blue catfish	LAR	0	0	0	9.6	0	4.8	2.4
2016	8/2/2016	53	Blue catfish	PYSL	0	19.6	9.8	0	0	0	4.9
2016	8/2/2016	53	Carp sucker/buffalofish	LAR	19.6	0	9.8	96.2	38.8	67.5	38.6
2016	8/2/2016	53	Carp suckers	LAR	0	0	0	0	9.7	4.8	2.4
2016	8/2/2016	53	Freshwater drum	LAR	0	78.3	39.1	0	0	0	19.6
2016	8/2/2016	53	Freshwater drum	PYSL	136.9	0	68.5	9.6	9.7	9.6	39.1
2016	8/2/2016	53	Gizzard shad	JUV	0	0	0	19.2	29.1	24.1	12.1

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	8/2/2016	53	Grass carp	YSL	29.3	9.8	19.6	9.6	9.7	9.6	14.6
2016	8/2/2016	53	Minnows	LAR	0	0	0	115.5	0	57.8	28.9
2016	8/2/2016	53	Minnows	YSL	0	9.8	4.9	0	0	0	2.5
2016	8/2/2016	53	Minnows group 2	PYSL	0	0	0	28.9	48.5	38.7	19.4
2016	8/2/2016	53	Silver/bighead carp	EGG	0	58.7	29.4	0	0	0	14.7
2016	8/2/2016	53	Silver/bighead carp	LAR	0	166.3	83.2	0	0	0	41.6
2016	8/2/2016	53	Sunfishes (Lepomis)	PYSL	0	9.8	4.9	0	0	0	2.5
2016	8/2/2016	53	Unidentifiable fish	EGG	68.4	0	34.2	115.5	9.7	62.6	48.4
2016	8/2/2016	53	Unidentifiable fish	LAR	58.7	0	29.4	0	29.1	14.6	22
2016	8/2/2016	53	Western mosquitofish	OLD	0	0	0	0	9.7	4.8	2.4
2016	8/9/2016	54	Carp suckers	LAR	0	39.1	19.6	19.5	39.1	29.3	24.4
2016	8/9/2016	54	Carp suckers	YSL	19.5	0	9.8	9.8	29.3	19.6	14.7
2016	8/9/2016	54	Freshwater drum	PYSL	58.4	97.8	78.1	88	107.6	97.8	88
2016	8/9/2016	54	Grass carp	LAR	19.5	0	9.8	9.8	19.6	14.7	12.2
2016	8/9/2016	54	Grass carp	YSL	19.5	39.1	29.3	19.5	19.6	19.6	24.4
2016	8/9/2016	54	Minnows	LAR	9.7	9.8	9.8	0	0	0	4.9
2016	8/9/2016	54	Silver/bighead carp	LAR	136.2	78.2	107.2	205.2	156.5	180.8	144
2016	8/9/2016	54	Silver/bighead carp	YSL	29.2	58.7	44	0	68.5	34.2	39.1
2016	8/9/2016	54	Sunfishes (Lepomis)	PYSL	0	0	0	9.8	0	4.9	2.5
2016	8/9/2016	54	Unidentifiable fish	EGG	0	9.8	4.9	0	0	0	2.5
2016	8/9/2016	54	Unidentifiable fish	LAR	0	39.1	19.6	48.9	48.9	48.9	34.2
2016	8/16/2016	55	Carp suckers	YSL	29.3	19.5	24.4	28.9	28.9	28.9	26.6

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	8/16/2016	55	Freshwater drum	EGG	0	0	0	9.6	0	4.8	2.4
2016	8/16/2016	55	Freshwater drum	LAR	0	19.5	9.8	0	9.6	4.8	7.3
2016	8/16/2016	55	Freshwater drum	PYSL	97.7	78	87.8	77.1	38.6	57.8	72.8
2016	8/16/2016	55	Minnows group 4	YSL	0	0	0	0	9.6	4.8	2.4
2016	8/23/2016	56	Carp sucker/buffalofish	YSL	0	9.8	4.9	9.8	0	4.9	4.9
2016	8/23/2016	56	Freshwater drum	YSL	19.6	48.9	34.2	39.1	78.3	58.7	46.5
2016	8/23/2016	56	Minnows	LAR	0	0	0	0	9.8	4.9	2.5
2016	8/23/2016	56	Silver/bighead carp	LAR	9.8	0	4.9	0	0	0	2.5
2016	8/23/2016	56	Silver/bighead carp	YSL	19.6	0	9.8	0	0	0	4.9
2016	8/23/2016	56	Sunfishes (Lepomis)	YSL	0	0	0	19.6	0	9.8	4.9
2016	8/23/2016	56	Unidentifiable fish	EGG	0	9.8	4.9	0	0	0	2.5
2016	8/30/2016	57	Blue catfish	JUV	0	0	0	19.8	0	9.9	5
2016	8/30/2016	57	Grass carp	YSL	2004.1	2274.5	2139.3	4378.1	4009.3	4193.7	3166.5
2016	8/30/2016	57	Minnows group 2	PYSL	0	0	0	19.8	0	9.9	5
2016	8/30/2016	57	Minnows group 2	YSL	0	9.8	4.9	0	0	0	2.5
2016	8/30/2016	57	Silver/bighead carp	LAR	176	0	88	0	0	0	44
2016	8/30/2016	57	Silver/bighead carp	YSL	39.1	234.3	136.7	396.2	312.9	354.5	245.6
2016	8/30/2016	57	Sunfishes (Lepomis)	PYSL	9.8	0	4.9	0	0	0	2.5
2016	8/30/2016	57	Unidentifiable fish	LAR	88	107.4	97.7	118.9	0	59.5	78.6
2016	8/30/2016	57	Unidentifiable fish	YSL	0	0	0	0	136.9	68.5	34.2
2016	9/6/2016	58	Freshwater drum	EGG	0	9.8	4.9	0	0	0	2.5
2016	9/6/2016	58	Freshwater drum	YSL	0	0	0	9.7	0	4.8	2.4

Year	Sample Date	Event	Taxon	Development Stage	Entrainment Density (Number per 1,000 m³)						
					Daytime Sampling			Nighttime Sampling			Sampling Event Mean
					06:00-12:00	12:00-18:00	Day Mean	18:00-24:00	00:00-06:00	Night Mean	
2016	9/6/2016	58	Grass carp	YSL	757	760.8	758.9	458.1	547.1	502.6	630.8
2016	9/6/2016	58	Minnows group 2	PYSL	0	0	0	0	9.8	4.9	2.5
2016	9/6/2016	58	Silver/bighead carp	YSL	127.8	78	102.9	97.5	97.7	97.6	100.2
2016	9/6/2016	58	Unidentifiable fish	EGG	19.7	0	9.8	0	19.5	9.8	9.8
2016	9/6/2016	58	Unidentifiable fish	JUV	9.8	0	4.9	0	0	0	2.5
2016	9/6/2016	58	Unidentifiable fish	LAR	0	9.8	4.9	0	19.5	9.8	7.3
2016	9/13/2016	59	Freshwater drum	EGG	76.3	0	38.1	39.1	19.6	29.4	33.8
2016	9/13/2016	59	Freshwater drum	YSL	9.5	0	4.8	0	0	0	2.4
2016	9/13/2016	59	Grass carp	YSL	9.5	0	4.8	0	0	0	2.4
2016	9/13/2016	59	Silver/bighead carp	YSL	0	19.8	9.9	0	0	0	5
2016	9/13/2016	59	Sunfishes (Lepomis)	PYSL	9.5	0	4.8	0	0	0	2.4

**Table 9 A-3 Length Distribution by Development Stage of Each Taxon Collected During 2015 and 2016 Entrainment Sampling Conducted at the LEC.**

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
10.5 - 11.5	Blue catfish	1	0	0	0	0	1
11.5 - 12.5	Blue catfish	0	0	0	0	0	0
12.5 - 13.5	Blue catfish	0	0	0	0	0	0
13.5 - 14.5	Blue catfish	0	0	0	0	0	0
14.5 - 15.5	Blue catfish	0	0	0	0	0	0
15.5 - 16.5	Blue catfish	0	0	0	0	0	0
16.5 - 17.5	Blue catfish	0	1	0	0	0	1
17.5 - 18.5	Blue catfish	0	0	0	0	0	0
18.5 - 19.5	Blue catfish	0	2	0	0	0	2
19.5 - 20.5	Blue catfish	0	0	0	0	0	0
20.5 - 21.5	Blue catfish	0	0	0	0	0	0
21.5 - 22.5	Blue catfish	0	1	0	0	0	1
22.5 - 23.5	Blue catfish	0	0	0	0	0	0
23.5 - 24.5	Blue catfish	0	0	0	0	0	0
24.5 - 25.5	Blue catfish	0	0	0	0	0	0
25.5 - 26.5	Blue catfish	0	0	0	0	0	0
26.5 - 27.5	Blue catfish	0	0	0	0	0	0
27.5 - 28.5	Blue catfish	0	0	0	2	0	2
28.5 - 29.5	Blue catfish	0	0	1	0	0	1
29.5 - 30.5	Blue catfish	0	0	0	0	0	0
30.5 - 31.5	Blue catfish	0	0	0	0	0	0
31.5 - 32.5	Blue catfish	0	0	0	0	0	0
32.5 - 33.5	Blue catfish	0	0	0	0	0	0
33.5 - 34.5	Blue catfish	0	0	2	0	0	2
7.5 - 8.5	Blue sucker	1	0	0	0	0	1
8.5 - 9.5	Blue sucker	5	0	3	0	0	8
9.5 - 10.5	Blue sucker	0	4	2	0	0	6
10.5 - 11.5	Blue sucker	0	0	0	0	0	0
11.5 - 12.5	Blue sucker	2	0	0	0	0	2
4.5 - 5.5	Buffalofish	1	0	0	0	0	1
5.5 - 6.5	Buffalofish	68	0	4	0	0	72
6.5 - 7.5	Buffalofish	69	14	4	0	0	87

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
7.5 - 8.5	Buffalofish	4	15	0	0	0	19
8.5 - 9.5	Buffalofish	1	4	0	0	0	5
9.5 - 10.5	Buffalofish	0	3	0	0	0	3
10.5 - 11.5	Buffalofish	0	0	0	0	0	0
11.5 - 12.5	Buffalofish	0	0	0	0	0	0
12.5 - 13.5	Buffalofish	0	19	0	0	0	19
13.5 - 14.5	Buffalofish	0	1	0	0	0	1
14.5 - 15.5	Buffalofish	0	0	0	0	0	0
15.5 - 16.5	Buffalofish	0	0	0	0	0	0
16.5 - 17.5	Buffalofish	0	0	0	0	0	0
17.5 - 18.5	Buffalofish	0	0	0	0	0	0
18.5 - 19.5	Buffalofish	0	0	0	0	0	0
19.5 - 20.5	Buffalofish	0	0	0	0	0	0
20.5 - 21.5	Buffalofish	0	0	0	0	0	0
21.5 - 22.5	Buffalofish	0	0	0	0	0	0
22.5 - 23.5	Buffalofish	0	0	0	0	0	0
23.5 - 24.5	Buffalofish	0	0	0	0	0	0
24.5 - 25.5	Buffalofish	0	0	0	0	0	0
25.5 - 26.5	Buffalofish	0	0	0	2	0	2
4.5 - 5.5	Carp sucker/buffalofish	20	0	1	0	0	21
5.5 - 6.5	Carp sucker/buffalofish	42	40	18	0	0	100
6.5 - 7.5	Carp sucker/buffalofish	72	85	35	0	0	192
7.5 - 8.5	Carp sucker/buffalofish	8	26	15	0	0	49
8.5 - 9.5	Carp sucker/buffalofish	0	6	10	0	0	16
9.5 - 10.5	Carp sucker/buffalofish	0	4	5	0	0	9
10.5 - 11.5	Carp sucker/buffalofish	0	2	0	0	0	2
11.5 - 12.5	Carp sucker/buffalofish	0	0	0	0	0	0
12.5 - 13.5	Carp sucker/buffalofish	0	5	0	0	0	5
13.5 - 14.5	Carp sucker/buffalofish	0	4	0	0	0	4
3.5 - 4.5	Carp suckers	3	0	1	0	0	4
4.5 - 5.5	Carp suckers	3	0	0	0	0	3
5.5 - 6.5	Carp suckers	64	2	3	0	0	69
6.5 - 7.5	Carp suckers	116	42	2	0	0	160
7.5 - 8.5	Carp suckers	18	24	1	0	0	43

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
8.5 - 9.5	Carp suckers	1	5	0	0	0	6
9.5 - 10.5	Carp suckers	0	0	0	0	0	0
10.5 - 11.5	Carp suckers	0	0	0	0	0	0
11.5 - 12.5	Carp suckers	0	0	0	0	0	0
12.5 - 13.5	Carp suckers	0	0	0	0	0	0
13.5 - 14.5	Carp suckers	0	1	0	0	0	1
12.5 - 13.5	Catfishes	0	1	0	0	0	1
14.5 - 15.5	Channel catfish	0	1	0	0	0	1
15.5 - 16.5	Channel catfish	0	0	0	1	0	1
16.5 - 17.5	Channel catfish	0	0	1	0	0	1
17.5 - 18.5	Channel catfish	0	0	0	0	0	0
18.5 - 19.5	Channel catfish	0	0	0	0	0	0
19.5 - 20.5	Channel catfish	0	0	0	1	0	1
20.5 - 21.5	Channel catfish	0	0	0	0	0	0
22.5 - 23.5	Channel catfish	0	1	0	1	0	2
23.5 - 24.5	Channel catfish	0	0	0	0	0	0
24.5 - 25.5	Channel catfish	0	0	0	1	0	1
2.5 - 3.5	Common carp	1	0	0	0	0	1
3.5 - 4.5	Common carp	0	0	0	0	0	0
4.5 - 5.5	Common carp	2	0	0	0	0	2
5.5 - 6.5	Common carp	0	36	0	0	0	36
6.5 - 7.5	Common carp	16	5	0	0	0	21
7.5 - 8.5	Common carp	0	0	0	0	0	0
8.5 - 9.5	Common carp	0	9	0	0	0	9
9.5 - 10.5	Common carp	0	0	2	0	0	2
10.5 - 11.5	Common carp	0	0	0	0	0	0
11.5 - 12.5	Common carp	0	16	0	0	0	16
12.5 - 13.5	Common carp	0	0	2	0	0	2
13.5 - 14.5	Common carp	0	10	1	0	0	11
14.5 - 15.5	Common carp	0	4	3	0	0	7
15.5 - 16.5	Common carp	0	4	0	0	0	4
16.5 - 17.5	Common carp	0	1	0	8	0	9
17.5 - 18.5	Common carp	0	32	0	0	0	32
18.5 - 19.5	Common carp	0	0	8	4	0	12



Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
19.5 - 20.5	Common carp	0	0	0	0	0	0
20.5 - 21.5	Common carp	0	0	0	0	0	0
21.5 - 22.5	Common carp	0	17	0	2	0	19
22.5 - 23.5	Common carp	0	0	0	0	0	0
23.5 - 24.5	Common carp	0	0	0	0	0	0
24.5 - 25.5	Common carp	0	0	0	0	0	0
25.5 - 26.5	Common carp	0	0	0	4	0	4
26.5 - 27.5	Common carp	0	1	0	2	0	3
27.5 - 28.5	Common carp	0	0	0	0	0	0
28.5 - 29.5	Common carp	0	0	0	0	0	0
29.5 - 30.5	Common carp	0	0	0	0	0	0
30.5 - 31.5	Common carp	0	0	0	0	0	0
31.5 - 32.5	Common carp	0	0	0	0	0	0
32.5 - 33.5	Common carp	0	0	0	0	0	0
33.5 - 34.5	Common carp	0	0	0	0	0	0
34.5 - 35.5	Common carp	0	0	0	0	0	0
35.5 - 36.5	Common carp	0	1	0	0	0	1
36.5 - 37.5	Common carp	0	0	0	0	0	0
37.5 - 38.5	Common carp	0	0	0	0	0	0
38.5 - 39.5	Common carp	0	0	0	0	0	0
39.5 - 40.5	Common carp	0	0	0	0	0	0
40.5 - 41.5	Common carp	0	0	0	0	0	0
41.5 - 42.5	Common carp	0	0	0	0	0	0
42.5 - 43.5	Common carp	0	0	0	0	0	0
43.5 - 44.5	Common carp	0	0	0	0	0	0
44.5 - 45.5	Common carp	0	0	0	0	0	0
45.5 - 46.5	Common carp	0	0	0	3	0	3
7.5 - 8.5	Crappies	0	1	0	0	0	1
8.5 - 9.5	Crappies	0	0	0	0	0	0
9.5 - 10.5	Crappies	0	0	0	0	0	0
10.5 - 11.5	Crappies	0	0	0	0	0	0
11.5 - 12.5	Crappies	0	0	0	0	0	0
12.5 - 13.5	Crappies	0	1	0	0	0	1
13.5 - 14.5	Crappies	0	0	0	8	0	8

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
4.5 - 5.5	Darter (Etheostoma)	0	1	0	0	0	1
5.5 - 6.5	Darter (Etheostoma)	1	0	0	0	0	1
6.5 - 7.5	Darter (Etheostoma)	0	0	0	0	0	0
7.5 - 8.5	Darter (Etheostoma)	0	1	0	0	0	1
5.5 - 6.5	Darter (Percina)	1	0	0	0	0	1
2.5 - 3.5	Freshwater drum	21	6	11	0	0	38
3.5 - 4.5	Freshwater drum	268	120	74	0	0	462
4.5 - 5.5	Freshwater drum	201	81	18	0	0	300
5.5 - 6.5	Freshwater drum	6	73	35	0	0	114
6.5 - 7.5	Freshwater drum	0	25	5	0	0	30
7.5 - 8.5	Freshwater drum	0	60	31	0	0	91
8.5 - 9.5	Freshwater drum	0	39	8	0	0	47
9.5 - 10.5	Freshwater drum	0	21	1	0	0	22
10.5 - 11.5	Freshwater drum	0	26	1	0	0	27
11.5 - 12.5	Freshwater drum	0	19	0	0	0	19
12.5 - 13.5	Freshwater drum	0	14	8	0	0	22
13.5 - 14.5	Freshwater drum	0	14	0	0	0	14
14.5 - 15.5	Freshwater drum	0	5	0	0	0	5
15.5 - 16.5	Freshwater drum	0	3	0	0	0	3
16.5 - 17.5	Freshwater drum	0	2	0	1	0	3
17.5 - 18.5	Freshwater drum	0	1	0	0	0	1
18.5 - 19.5	Freshwater drum	0	3	0	0	0	3
19.5 - 20.5	Freshwater drum	0	0	0	0	0	0
20.5 - 21.5	Freshwater drum	0	1	0	0	0	1
21.5 - 22.5	Freshwater drum	0	1	0	0	0	1
22.5 - 23.5	Freshwater drum	0	0	0	0	0	0
23.5 - 24.5	Freshwater drum	0	0	0	0	0	0
24.5 - 25.5	Freshwater drum	0	0	0	0	0	0
25.5 - 26.5	Freshwater drum	0	1	0	0	0	1
26.5 - 27.5	Freshwater drum	0	1	0	0	0	1
27.5 - 28.5	Freshwater drum	0	0	0	0	0	0
28.5 - 29.5	Freshwater drum	0	0	0	0	0	0
29.5 - 30.5	Freshwater drum	0	0	0	0	0	0
30.5 - 31.5	Freshwater drum	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
31.5 - 32.5	Freshwater drum	0	0	0	0	0	0
32.5 - 33.5	Freshwater drum	0	0	0	1	0	1
33.5 - 34.5	Freshwater drum	0	0	0	0	0	0
34.5 - 35.5	Freshwater drum	0	0	0	0	0	0
35.5 - 36.5	Freshwater drum	0	0	0	0	0	0
36.5 - 37.5	Freshwater drum	0	0	0	0	0	0
37.5 - 38.5	Freshwater drum	0	0	0	0	0	0
38.5 - 39.5	Freshwater drum	0	0	0	0	0	0
39.5 - 40.5	Freshwater drum	0	0	0	1	0	1
2.5 - 3.5	Gizzard shad	0	0	1	0	0	1
3.5 - 4.5	Gizzard shad	0	0	0	0	0	0
4.5 - 5.5	Gizzard shad	0	0	0	0	0	0
5.5 - 6.5	Gizzard shad	0	1	0	0	0	1
6.5 - 7.5	Gizzard shad	0	7	0	0	0	7
7.5 - 8.5	Gizzard shad	0	1	18	0	0	19
8.5 - 9.5	Gizzard shad	0	6	0	0	0	6
9.5 - 10.5	Gizzard shad	0	28	20	0	0	48
10.5 - 11.5	Gizzard shad	0	36	18	0	0	54
11.5 - 12.5	Gizzard shad	0	74	22	0	0	96
12.5 - 13.5	Gizzard shad	0	75	38	0	0	113
13.5 - 14.5	Gizzard shad	0	115	13	0	0	128
14.5 - 15.5	Gizzard shad	0	70	2	0	0	72
15.5 - 16.5	Gizzard shad	0	43	0	0	0	43
16.5 - 17.5	Gizzard shad	0	41	64	0	0	105
17.5 - 18.5	Gizzard shad	0	61	0	1	0	62
18.5 - 19.5	Gizzard shad	0	62	17	0	0	79
19.5 - 20.5	Gizzard shad	0	30	20	1	0	51
20.5 - 21.5	Gizzard shad	0	25	0	8	0	33
21.5 - 22.5	Gizzard shad	0	6	4	10	0	20
22.5 - 23.5	Gizzard shad	0	35	0	5	0	40
23.5 - 24.5	Gizzard shad	0	4	0	10	0	14
24.5 - 25.5	Gizzard shad	0	3	0	4	0	7
25.5 - 26.5	Gizzard shad	0	3	0	4	0	7
26.5 - 27.5	Gizzard shad	0	0	0	3	0	3

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
27.5 - 28.5	Gizzard shad	0	0	0	1	0	1
28.5 - 29.5	Gizzard shad	0	0	0	2	0	2
29.5 - 30.5	Gizzard shad	0	1	0	2	0	3
30.5 - 31.5	Gizzard shad	0	0	0	3	0	3
31.5 - 32.5	Gizzard shad	0	0	0	2	0	2
32.5 - 33.5	Gizzard shad	0	0	0	2	0	2
33.5 - 34.5	Gizzard shad	0	0	0	0	0	0
34.5 - 35.5	Gizzard shad	0	0	0	0	0	0
35.5 - 36.5	Gizzard shad	0	0	0	2	0	2
7.5 - 8.5	Goldeye	14	2	0	0	0	16
8.5 - 9.5	Goldeye	24	0	1	0	0	25
9.5 - 10.5	Goldeye	39	20	0	0	0	59
10.5 - 11.5	Goldeye	84	65	0	0	0	149
11.5 - 12.5	Goldeye	18	17	0	0	0	35
12.5 - 13.5	Goldeye	9	15	0	0	0	24
13.5 - 14.5	Goldeye	2	10	0	0	0	12
14.5 - 15.5	Goldeye	0	9	0	0	0	9
15.5 - 16.5	Goldeye	0	2	0	0	0	2
16.5 - 17.5	Goldeye	0	1	0	0	0	1
17.5 - 18.5	Goldeye	0	0	0	0	0	0
18.5 - 19.5	Goldeye	0	0	0	0	0	0
19.5 - 20.5	Goldeye	0	8	0	0	0	8
20.5 - 21.5	Goldeye	0	0	0	0	0	0
21.5 - 22.5	Goldeye	0	0	0	0	0	0
22.5 - 23.5	Goldeye	0	0	0	0	0	0
23.5 - 24.5	Goldeye	0	0	0	0	0	0
24.5 - 25.5	Goldeye	0	0	0	0	0	0
25.5 - 26.5	Goldeye	0	0	0	0	0	0
26.5 - 27.5	Goldeye	0	0	0	0	0	0
27.5 - 28.5	Goldeye	0	0	0	0	0	0
28.5 - 29.5	Goldeye	0	0	0	0	0	0
29.5 - 30.5	Goldeye	0	0	0	0	0	0
30.5 - 31.5	Goldeye	0	0	0	0	0	0
31.5 - 32.5	Goldeye	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
32.5 - 33.5	Goldeye	0	0	0	0	0	0
33.5 - 34.5	Goldeye	0	0	0	0	0	0
34.5 - 35.5	Goldeye	0	0	0	4	0	4
9.5 - 10.5	Goldeye/mooneye	0	16	0	0	0	16
3.5 - 4.5	Grass carp	5	0	0	0	0	5
4.5 - 5.5	Grass carp	45	0	2	0	0	47
5.5 - 6.5	Grass carp	140	32	2	0	0	174
6.5 - 7.5	Grass carp	743	64	2	0	0	809
7.5 - 8.5	Grass carp	101	17	0	0	0	118
8.5 - 9.5	Grass carp	10	0	0	0	0	10
9.5 - 10.5	Grass carp	0	0	0	0	0	0
10.5 - 11.5	Grass carp	0	0	0	0	0	0
11.5 - 12.5	Grass carp	0	0	0	0	0	0
12.5 - 13.5	Grass carp	0	0	0	0	0	0
13.5 - 14.5	Grass carp	0	0	0	0	0	0
14.5 - 15.5	Grass carp	0	0	0	0	0	0
15.5 - 16.5	Grass carp	0	0	0	0	0	0
16.5 - 17.5	Grass carp	0	0	0	0	0	0
17.5 - 18.5	Grass carp	0	0	0	0	0	0
18.5 - 19.5	Grass carp	0	1	0	0	0	1
19.5 - 20.5	Grass carp	0	1	0	0	0	1
2.5 - 3.5	Herrings-shads	0	0	2	0	0	2
3.5 - 4.5	Herrings-shads	0	0	2	0	0	2
4.5 - 5.5	Herrings-shads	0	0	3	0	0	3
5.5 - 6.5	Herrings-shads	0	0	1	0	0	1
6.5 - 7.5	Herrings-shads	0	0	1	0	0	1
7.5 - 8.5	Herrings-shads	0	0	1	0	0	1
8.5 - 9.5	Herrings-shads	0	8	0	0	0	8
9.5 - 10.5	Herrings-shads	0	16	0	0	0	16
6.5 - 7.5	Logperch	1	0	1	0	0	2
7.5 - 8.5	Logperch	0	1	0	0	0	1
2.5 - 3.5	Minnows	0	0	1	0	0	1
3.5 - 4.5	Minnows	0	0	3	0	0	3
4.5 - 5.5	Minnows	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
5.5 - 6.5	Minnows	0	0	1	0	0	1
6.5 - 7.5	Minnows	0	0	0	0	0	0
7.5 - 8.5	Minnows	0	1	0	0	0	1
8.5 - 9.5	Minnows	0	1	0	0	0	1
9.5 - 10.5	Minnows	0	0	0	0	0	0
10.5 - 11.5	Minnows	0	0	1	0	0	1
5.5 - 6.5	Minnows group 2	4	32	2	0	0	38
6.5 - 7.5	Minnows group 2	15	2	6	0	0	23
7.5 - 8.5	Minnows group 2	0	0	0	0	0	0
8.5 - 9.5	Minnows group 2	0	2	0	0	0	2
9.5 - 10.5	Minnows group 2	0	2	0	0	0	2
10.5 - 11.5	Minnows group 2	0	1	0	0	0	1
11.5 - 12.5	Minnows group 2	0	0	0	0	0	0
12.5 - 13.5	Minnows group 2	0	0	0	0	0	0
13.5 - 14.5	Minnows group 2	0	0	0	0	0	0
14.5 - 15.5	Minnows group 2	0	1	0	0	0	1
15.5 - 16.5	Minnows group 2	0	0	0	0	0	0
16.5 - 17.5	Minnows group 2	0	0	0	0	0	0
17.5 - 18.5	Minnows group 2	0	1	0	0	0	1
18.5 - 19.5	Minnows group 2	0	0	0	0	0	0
19.5 - 20.5	Minnows group 2	0	0	0	0	0	0
20.5 - 21.5	Minnows group 2	0	0	0	0	0	0
21.5 - 22.5	Minnows group 2	0	1	0	0	0	1
5.5 - 6.5	Minnows group 3	0	1	0	0	0	1
6.5 - 7.5	Minnows group 3	0	0	0	0	0	0
7.5 - 8.5	Minnows group 3	0	0	0	0	0	0
8.5 - 9.5	Minnows group 3	0	2	0	0	0	2
3.5 - 4.5	Minnows group 4	0	1	0	0	0	1
4.5 - 5.5	Minnows group 4	0	0	0	0	0	0
5.5 - 6.5	Minnows group 4	1	1	0	0	0	2
5.5 - 6.5	Minnows group 5	0	1	0	0	0	1
4.5 - 5.5	Minnows group 6	0	1	0	0	0	1
5.5 - 6.5	Minnows group 6	0	0	1	0	0	1
6.5 - 7.5	Minnows group 6	0	0	1	0	0	1

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
7.5 - 8.5	Minnows group 6	0	0	0	0	0	0
8.5 - 9.5	Minnows group 6	0	1	0	0	0	1
9.5 - 10.5	Minnows group 6	0	0	0	0	0	0
10.5 - 11.5	Minnows group 6	0	0	0	0	0	0
11.5 - 12.5	Minnows group 6	0	1	0	0	0	1
12.5 - 13.5	Minnows group 6	0	1	0	0	0	1
6.5 - 7.5	Mooneye	2	0	0	0	0	2
7.5 - 8.5	Mooneye	0	0	0	0	0	0
8.5 - 9.5	Mooneye	6	0	2	0	0	8
9.5 - 10.5	Mooneye	18	0	0	0	0	18
10.5 - 11.5	Mooneye	0	0	0	0	0	0
11.5 - 12.5	Mooneye	0	0	0	0	0	0
12.5 - 13.5	Mooneye	0	0	0	0	0	0
13.5 - 14.5	Mooneye	0	0	0	0	0	0
14.5 - 15.5	Mooneye	0	0	0	0	0	0
15.5 - 16.5	Mooneye	0	0	0	0	0	0
16.5 - 17.5	Mooneye	0	1	0	0	0	1
13.5 - 14.5	Paddlefish	0	0	1	0	0	1
6.5 - 7.5	Redhorse suckers	2	1	0	0	0	3
7.5 - 8.5	Redhorse suckers	5	1	1	0	0	7
8.5 - 9.5	Redhorse suckers	2	6	2	0	0	10
9.5 - 10.5	Redhorse suckers	1	5	0	0	0	6
10.5 - 11.5	Redhorse suckers	0	3	0	0	0	3
11.5 - 12.5	Redhorse suckers	0	0	0	0	0	0
12.5 - 13.5	Redhorse suckers	0	1	0	0	0	1
29.5 - 30.5	Shoal chub	0	0	0	0	1	1
30.5 - 31.5	Shortnose gar	0	0	4	0	0	4
5.5 - 6.5	Silver carp	0	4	0	0	0	4
6.5 - 7.5	Silver carp	0	0	0	0	0	0
7.5 - 8.5	Silver carp	0	0	0	0	0	0
8.5 - 9.5	Silver carp	0	0	0	0	0	0
9.5 - 10.5	Silver carp	0	0	0	0	0	0
10.5 - 11.5	Silver carp	0	0	0	0	0	0
11.5 - 12.5	Silver carp	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
12.5 - 13.5	Silver carp	0	0	0	0	0	0
13.5 - 14.5	Silver carp	0	0	0	0	0	0
14.5 - 15.5	Silver carp	0	0	0	0	0	0
15.5 - 16.5	Silver carp	0	0	0	0	0	0
16.5 - 17.5	Silver carp	0	0	0	0	0	0
17.5 - 18.5	Silver carp	0	0	0	0	0	0
18.5 - 19.5	Silver carp	0	0	0	0	0	0
19.5 - 20.5	Silver carp	0	0	0	0	0	0
20.5 - 21.5	Silver carp	0	0	0	0	0	0
21.5 - 22.5	Silver carp	0	0	0	0	0	0
22.5 - 23.5	Silver carp	0	0	0	0	0	0
23.5 - 24.5	Silver carp	0	0	0	0	0	0
24.5 - 25.5	Silver carp	0	0	0	0	0	0
25.5 - 26.5	Silver carp	0	0	0	0	0	0
26.5 - 27.5	Silver carp	0	0	0	0	0	0
27.5 - 28.5	Silver carp	0	0	0	0	0	0
28.5 - 29.5	Silver carp	0	0	0	0	0	0
29.5 - 30.5	Silver carp	0	0	0	1	0	1
4.5 - 5.5	Silver/bighead carp	33	18	0	0	0	51
5.5 - 6.5	Silver/bighead carp	1116	114	130	0	0	1360
6.5 - 7.5	Silver/bighead carp	3970	3483	343	0	0	7796
7.5 - 8.5	Silver/bighead carp	766	464	144	0	0	1374
8.5 - 9.5	Silver/bighead carp	76	180	24	0	0	280
9.5 - 10.5	Silver/bighead carp	0	45	14	0	0	59
10.5 - 11.5	Silver/bighead carp	0	26	1	0	0	27
11.5 - 12.5	Silver/bighead carp	0	9	1	0	0	10
12.5 - 13.5	Silver/bighead carp	0	11	1	0	0	12
13.5 - 14.5	Silver/bighead carp	0	9	0	0	0	9
14.5 - 15.5	Silver/bighead carp	0	2	1	0	0	3
15.5 - 16.5	Silver/bighead carp	0	2	0	0	0	2
16.5 - 17.5	Silver/bighead carp	0	1	0	0	0	1
17.5 - 18.5	Silver/bighead carp	0	3	1	0	0	4
18.5 - 19.5	Silver/bighead carp	0	10	0	0	0	10
19.5 - 20.5	Silver/bighead carp	0	6	0	4	0	10



Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
20.5 - 21.5	Silver/bighead carp	0	1	0	0	0	1
21.5 - 22.5	Silver/bighead carp	0	3	0	0	0	3
22.5 - 23.5	Silver/bighead carp	0	2	0	0	0	2
23.5 - 24.5	Silver/bighead carp	0	1	0	0	0	1
24.5 - 25.5	Silver/bighead carp	0	1	0	0	0	1
25.5 - 26.5	Silver/bighead carp	0	0	0	1	0	1
26.5 - 27.5	Silver/bighead carp	0	0	0	0	0	0
27.5 - 28.5	Silver/bighead carp	0	0	0	0	0	0
28.5 - 29.5	Silver/bighead carp	0	0	0	0	0	0
29.5 - 30.5	Silver/bighead carp	0	1	0	0	0	1
30.5 - 31.5	Silver/bighead carp	0	0	0	0	0	0
31.5 - 32.5	Silver/bighead carp	0	1	0	0	0	1
32.5 - 33.5	Silver/bighead carp	0	0	0	0	0	0
33.5 - 34.5	Silver/bighead carp	0	0	0	0	0	0
34.5 - 35.5	Silver/bighead carp	0	0	0	0	0	0
35.5 - 36.5	Silver/bighead carp	0	0	0	0	0	0
36.5 - 37.5	Silver/bighead carp	0	0	0	0	0	0
37.5 - 38.5	Silver/bighead carp	0	0	0	1	0	1
38.5 - 39.5	Silver/bighead carp	0	0	0	1	0	1
39.5 - 40.5	Silver/bighead carp	0	0	0	1	0	1
4.5 - 5.5	Suckers	0	0	1	0	0	1
5.5 - 6.5	Suckers	0	0	9	0	0	9
6.5 - 7.5	Suckers	0	0	1	0	0	1
7.5 - 8.5	Sunfishes	0	1	0	0	0	1
12.5 - 13.5	Sunfishes	0	1	0	0	0	1
13.5 - 14.5	Sunfishes	0	2	0	0	0	2
14.5 - 15.5	Sunfishes	0	0	0	0	0	0
15.5 - 16.5	Sunfishes	0	1	0	0	0	1
16.5 - 17.5	Sunfishes	0	0	0	0	0	0
17.5 - 18.5	Sunfishes	0	0	0	0	0	0
18.5 - 19.5	Sunfishes	0	0	0	0	0	0
19.5 - 20.5	Sunfishes	0	0	0	0	0	0
20.5 - 21.5	Sunfishes	0	0	0	0	0	0
21.5 - 22.5	Sunfishes	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
22.5 - 23.5	Sunfishes	0	0	0	0	0	0
23.5 - 24.5	Sunfishes	0	0	0	0	0	0
24.5 - 25.5	Sunfishes	0	0	0	0	0	0
25.5 - 26.5	Sunfishes	0	0	0	0	0	0
26.5 - 27.5	Sunfishes	0	0	0	0	0	0
27.5 - 28.5	Sunfishes	0	0	0	0	0	0
28.5 - 29.5	Sunfishes	0	0	0	0	0	0
29.5 - 30.5	Sunfishes	0	0	0	0	0	0
30.5 - 31.5	Sunfishes	0	0	0	0	0	0
31.5 - 32.5	Sunfishes	0	0	0	0	0	0
32.5 - 33.5	Sunfishes	0	0	0	1	0	1
2.5 - 3.5	Sunfishes (Lepomis)	0	1	0	0	0	1
3.5 - 4.5	Sunfishes (Lepomis)	1	3	0	0	0	4
4.5 - 5.5	Sunfishes (Lepomis)	0	1	0	0	0	1
5.5 - 6.5	Sunfishes (Lepomis)	0	2	0	0	0	2
6.5 - 7.5	Sunfishes (Lepomis)	0	0	0	0	0	0
7.5 - 8.5	Sunfishes (Lepomis)	0	0	0	0	0	0
8.5 - 9.5	Sunfishes (Lepomis)	0	0	0	0	0	0
9.5 - 10.5	Sunfishes (Lepomis)	0	1	0	0	0	1
10.5 - 11.5	Sunfishes (Lepomis)	0	0	0	0	0	0
11.5 - 12.5	Sunfishes (Lepomis)	0	2	0	0	0	2
12.5 - 13.5	Sunfishes (Lepomis)	0	1	0	0	0	1
13.5 - 14.5	Sunfishes (Lepomis)	0	1	0	0	0	1
14.5 - 15.5	Sunfishes (Lepomis)	0	1	0	0	0	1
15.5 - 16.5	Sunfishes (Lepomis)	0	0	0	0	0	0
16.5 - 17.5	Sunfishes (Lepomis)	0	0	0	0	0	0
17.5 - 18.5	Sunfishes (Lepomis)	0	0	0	0	0	0
18.5 - 19.5	Sunfishes (Lepomis)	0	1	0	0	0	1
19.5 - 20.5	Sunfishes (Lepomis)	0	0	0	0	0	0
20.5 - 21.5	Sunfishes (Lepomis)	0	0	0	0	0	0
21.5 - 22.5	Sunfishes (Lepomis)	0	0	0	0	0	0
22.5 - 23.5	Sunfishes (Lepomis)	0	0	0	0	0	0
23.5 - 24.5	Sunfishes (Lepomis)	0	0	0	0	0	0
24.5 - 25.5	Sunfishes (Lepomis)	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
25.5 - 26.5	Sunfishes (Lepomis)	0	0	0	0	0	0
26.5 - 27.5	Sunfishes (Lepomis)	0	0	0	0	0	0
27.5 - 28.5	Sunfishes (Lepomis)	0	0	0	0	0	0
28.5 - 29.5	Sunfishes (Lepomis)	0	0	0	0	0	0
29.5 - 30.5	Sunfishes (Lepomis)	0	0	0	2	0	2
2.5 - 3.5	Unidentifiable fish	0	0	1	0	0	1
3.5 - 4.5	Unidentifiable fish	0	1	11	0	0	12
4.5 - 5.5	Unidentifiable fish	0	0	12	0	0	12
5.5 - 6.5	Unidentifiable fish	0	1	2	0	0	3
6.5 - 7.5	Unidentifiable fish	0	2	13	0	0	15
7.5 - 8.5	Unidentifiable fish	0	2	5	0	0	7
8.5 - 9.5	Unidentifiable fish	0	0	1	0	0	1
5.5 - 6.5	Walleye	0	0	1	0	0	1
6.5 - 7.5	Walleye	0	0	0	0	0	0
7.5 - 8.5	Walleye	0	0	0	0	0	0
8.5 - 9.5	Walleye	0	1	0	0	0	1
9.5 - 10.5	Walleye	0	32	0	0	0	32
5.5 - 6.5	Walleye/sauger	0	1	0	0	0	1
6.5 - 7.5	Walleye/sauger	1	1	0	0	0	2
7.5 - 8.5	Walleye/sauger	1	2	0	0	0	3
8.5 - 9.5	Walleye/sauger	0	0	0	0	0	0
9.5 - 10.5	Walleye/sauger	0	1	0	0	0	1
10.5 - 11.5	Walleye/sauger	0	0	0	0	0	0
11.5 - 12.5	Walleye/sauger	0	0	0	0	0	0
12.5 - 13.5	Walleye/sauger	0	1	0	0	0	1
13.5 - 14.5	Walleye/sauger	0	0	0	0	0	0
14.5 - 15.5	Walleye/sauger	0	1	0	0	0	1
8.5 - 9.5	Western mosquitofish	0	0	0	0	1	1
23.5 - 24.5	White bass	0	1	0	0	0	1
24.5 - 25.5	White bass	0	0	0	0	0	0
25.5 - 26.5	White bass	0	0	0	0	0	0
26.5 - 27.5	White bass	0	0	0	0	0	0
27.5 - 28.5	White bass	0	0	0	0	0	0
28.5 - 29.5	White bass	0	0	0	0	0	0

Length Range (mm)	Taxon	YSL	PYSL	LAR	JUV	OLD	All Development Stages
29.5 - 30.5	White bass	0	1	0	0	0	1
30.5 - 31.5	White bass	0	0	0	0	0	0
31.5 - 32.5	White bass	0	0	0	0	0	0
32.5 - 33.5	White bass	0	0	0	0	0	0
33.5 - 34.5	White bass	0	0	0	0	0	0
34.5 - 35.5	White bass	0	0	0	0	0	0
35.5 - 36.5	White bass	0	0	0	0	0	0
36.5 - 37.5	White bass	0	0	0	0	0	0
37.5 - 38.5	White bass	0	0	0	0	0	0
38.5 - 39.5	White bass	0	0	0	0	0	0
39.5 - 40.5	White bass	0	0	0	0	0	0
40.5 - 41.5	White bass	0	0	0	0	0	0
41.5 - 42.5	White bass	0	0	0	0	0	0
42.5 - 43.5	White bass	0	0	0	0	0	0
43.5 - 44.5	White bass	0	0	0	0	0	0
44.5 - 45.5	White bass	0	0	0	0	0	0
45.5 - 46.5	White bass	0	0	0	0	0	0
46.5 - 47.5	White bass	0	0	0	0	0	0
47.5 - 48.5	White bass	0	0	0	0	0	0
48.5 - 49.5	White bass	0	0	0	2	0	2
10.5 - 11.5	White crappie	0	2	0	0	0	2
6.5 - 7.5	White sucker	1	0	1	0	0	2
7.5 - 8.5	White sucker	1	0	1	0	0	2
8.5 - 9.5	White sucker	0	2	2	0	0	4
9.5 - 10.5	White sucker	0	3	2	0	0	5
10.5 - 11.5	White sucker	0	9	0	0	0	9
11.5 - 12.5	White sucker	0	1	1	0	0	2
12.5 - 13.5	White sucker	0	0	2	0	0	2
13.5 - 14.5	White sucker	0	0	0	0	0	0
14.5 - 15.5	White sucker	0	2	0	0	0	2

**Table 9 A-4 Taxonomic and Development Stage Composition of Fish Collected During 2015 and 2016 River Ichthyoplankton Sampling Conducted near the LEC CWIS.**

2015 Study Year							
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Total	Percent
Silver/bighead carp	3	73	175	1	0	252	30.8
Grass carp	--	98	76	5	0	179	21.9
Carp suckers	--	78	95	0	0	173	21.1
Freshwater drum	40	10	66	0	0	116	14.2
Minnow family	--	2	10	5	0	17	2.1
Minnows group 2	--	1	11	0	0	12	1.5
Unidentified fishes	7	0	0	5	0	12	1.5
Gizzard shad	--	0	9	0	2	11	1.3
Carp suckers and buffalos	--	0	8	0	0	8	1.0
Common carp	--	1	6	0	1	8	1.0
Minnows group 6	--	4	3	0	0	7	0.9
Sunfish family	--	0	5	0	0	5	0.6
Minnows group 4	--	2	2	0	0	4	0.5
Bighead carp	--	3	0	0	0	3	0.4
Minnows group 5	--	2	1	0	0	3	0.4
Shovelnose sturgeon	--	2	0	0	0	2	0.2
Silver carp	--	0	0	0	2	2	0.2
Brook silverside	--	0	1	0	0	1	0.1
Buffalos	--	0	0	0	1	1	0.1
River sturgeons	--	1	0	0	0	1	0.1
Sand shiner	--	0	0	0	1	1	0.1
Shovelnose × pallid	--	0	1	0	0	1	0.1
<b>Study Year Total</b>	<b>50</b>	<b>277</b>	<b>469</b>	<b>16</b>	<b>7</b>	<b>819</b>	<b>100.0</b>
2016 Study Year							
Taxon	Eggs	YSL	PYSL	LAR	Juveniles	Total	Percent
Silver/bighead carp	0	10,704	509	644	0	11,857	68.5
Unidentified fish	1,772	2	0	362	0	2,136	12.3
Grass carp	222	1,540	0	0	0	1,762	10.2
Freshwater drum	66	152	131	12	0	361	2.1
Carp suckers	--	250	94	0	0	344	2.0
Carp suckers and buffalos	1	70	42	23	0	136	0.8
Gizzard shad	--	0	126	6	3	135	0.8
Buffalos	--	125	6	0	0	131	0.8
Sucker family	--	118	0	1	0	119	0.7
Goldeye	--	98	0	1	0	99	0.6
Common carp	--	9	18	25	3	55	0.3
Blue sucker	--	24	0	2	1	27	0.2
Minnows group 2	--	20	5	1	0	26	0.2
Redhorse suckers	--	17	5	0	0	22	0.1
White crappie	--	0	19	0	0	19	0.1
Blue catfish	--	3	0	1	4	8	<0.1
Mooneyes ( <i>Hiodon</i> sp.)	1	0	0	6	0	7	<0.1
Sunfishes ( <i>Lepomis</i> sp.)	--	4	1	0	2	7	<0.1
White sucker	--	6	0	0	0	6	<0.1
Emerald shiner	--	0	1	4	0	5	<0.1
Minnows group 6	--	5	0	0	0	5	<0.1

Bighead carp	--	2	2	0	0	4	<0.1
Minnows group 3	--	0	0	4	0	4	<0.1
<b>2016 Study Year</b>							
<b>Taxon</b>	<b>Eggs</b>	<b>YSL</b>	<b>PYSL</b>	<b>LAR</b>	<b>Juveniles</b>	<b>Total</b>	<b>Percent</b>
Mooneye	--	4	0	0	0	4	<0.1
Paddlefish	--	4	0	0	0	4	<0.1
Minnows group 4	--	2	0	0	0	2	<0.1
Rainbow darter	--	0	2	0	0	2	<0.1
Walleye	--	2	0	0	0	2	<0.1
Walleye and sauger	--	0	2	0	0	2	<0.1
Channel catfish	--	0	0	0	1	1	<0.1
Darter ( <i>Percina</i> sp.)	--	0	0	1	0	1	<0.1
Logperch	--	0	1	0	0	1	<0.1
Minnows group 5	--	1	0	0	0	1	<0.1
Paddlefish and sturgeon	--	1	0	0	0	1	<0.1
Sauger	--	0	1	0	0	1	<0.1
Stonecat madtom	--	0	0	1	0	1	<0.1
<b>Study Year Total</b>	<b>2,062</b>	<b>13,163</b>	<b>965</b>	<b>1,094</b>	<b>14</b>	<b>17,298</b>	<b>100.0</b>

**Appendix 9 B**  
**40 CFR 122.21(r)(9) – Entrainment Characterization Study**

**Seasonal Patterns of Entrainment of All Taxa and Development  
Stages at Labadie Energy Center, 2015 and 2016**

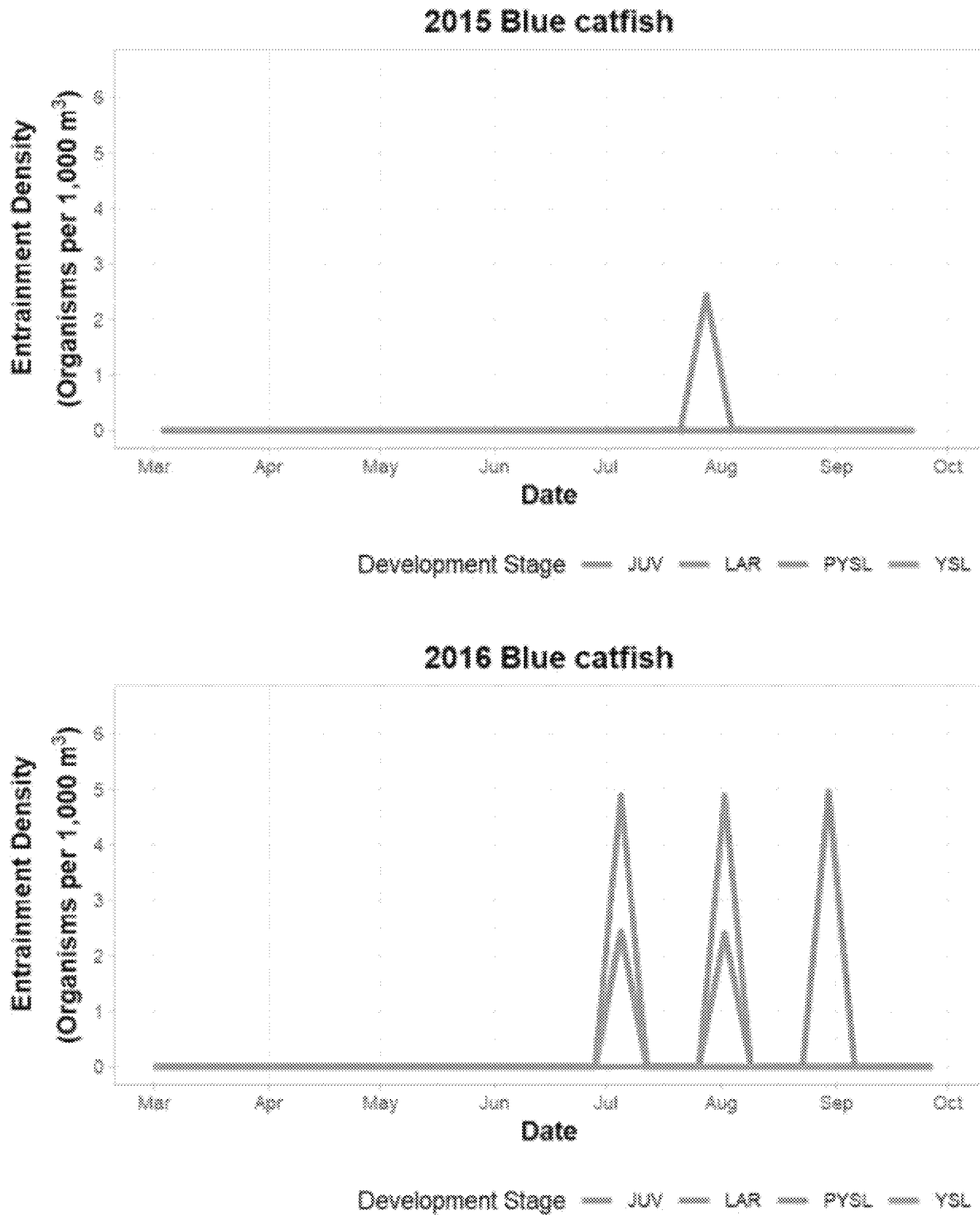
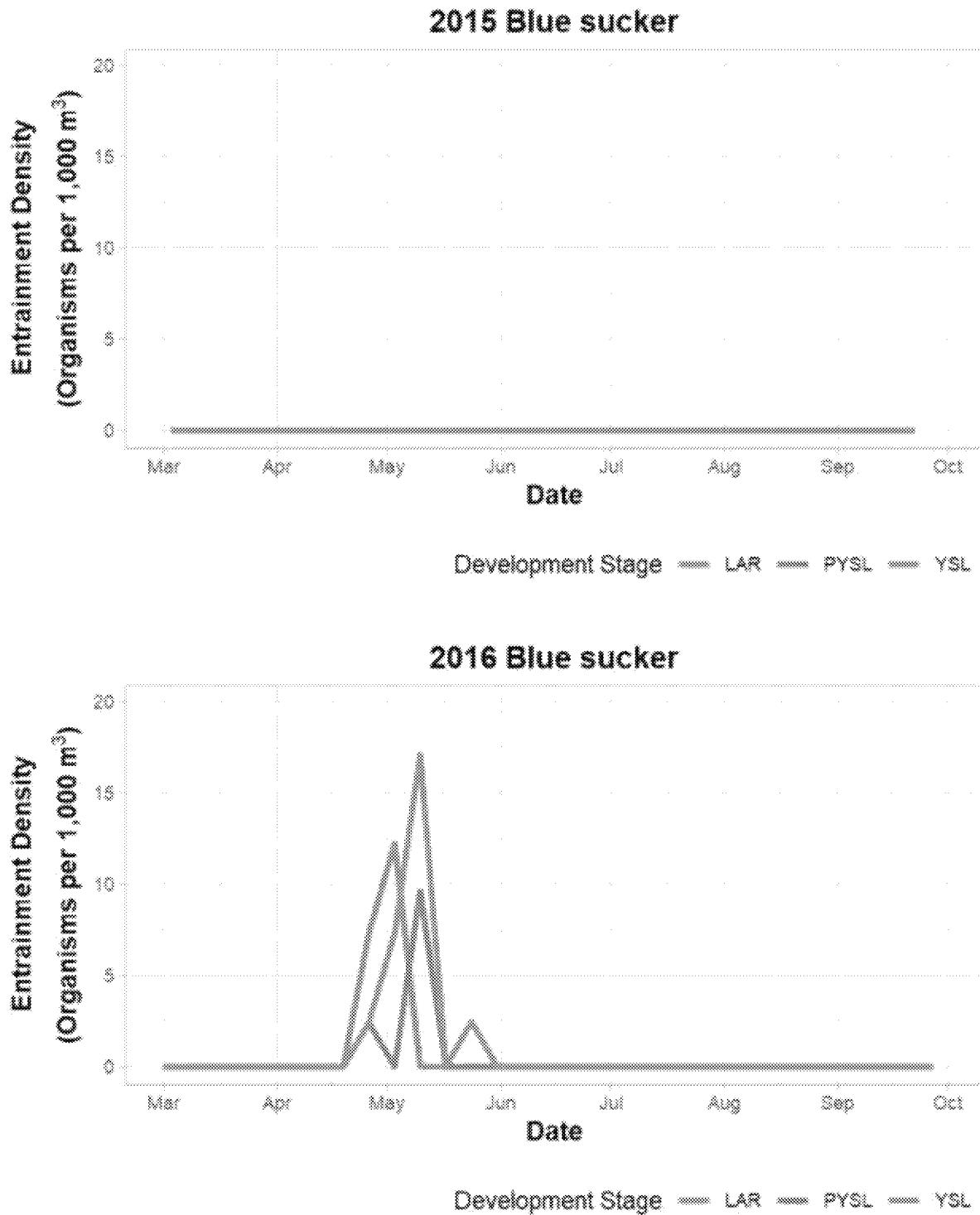


Figure 9 B-1 Seasonal Pattern of Entrainment of Blue Catfish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.





**Figure 9 B-2 Seasonal Pattern of Entrainment of Blue Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

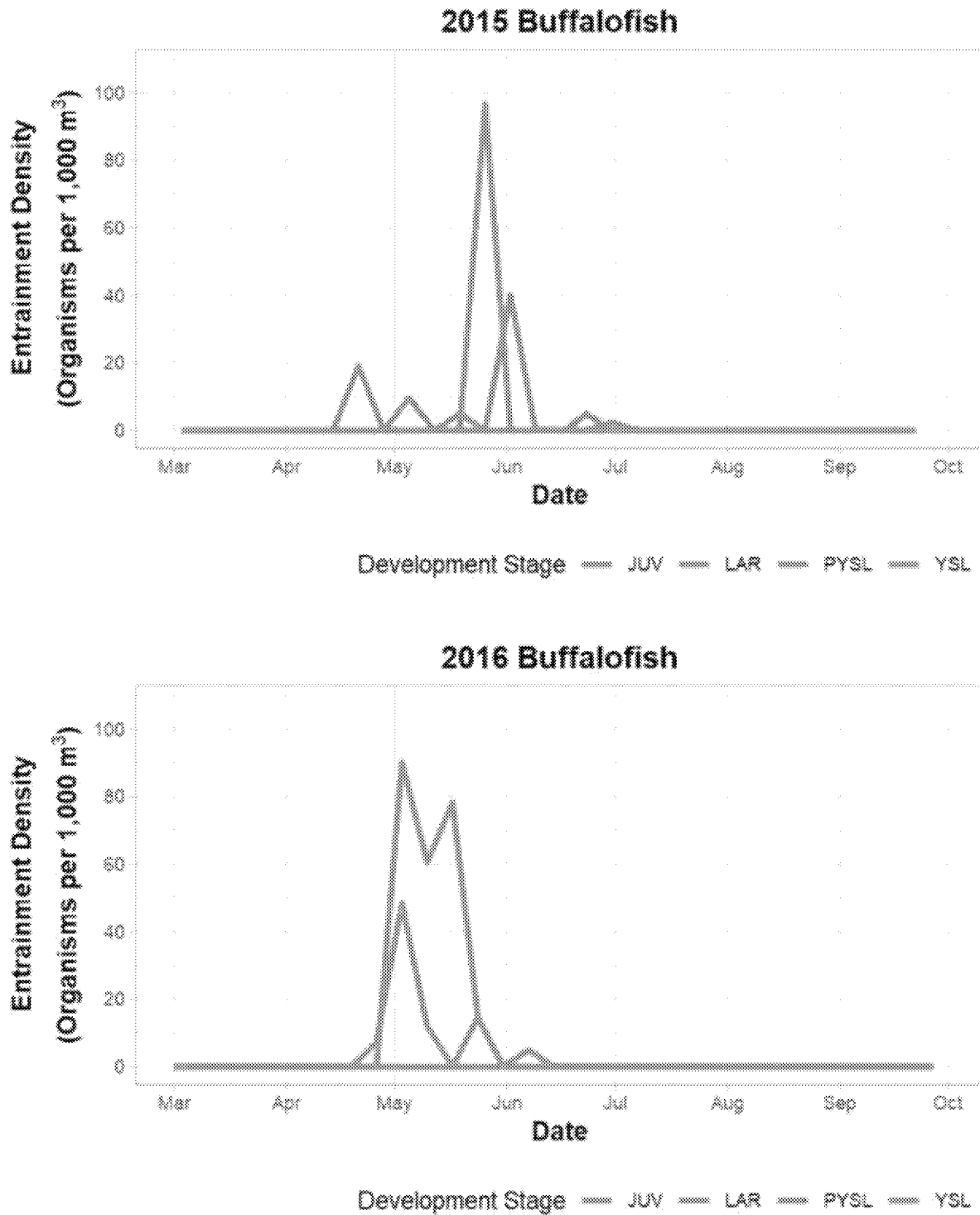


Figure 9 B-3 Seasonal Pattern of Entrainment of Buffalos (*Ictiobus* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

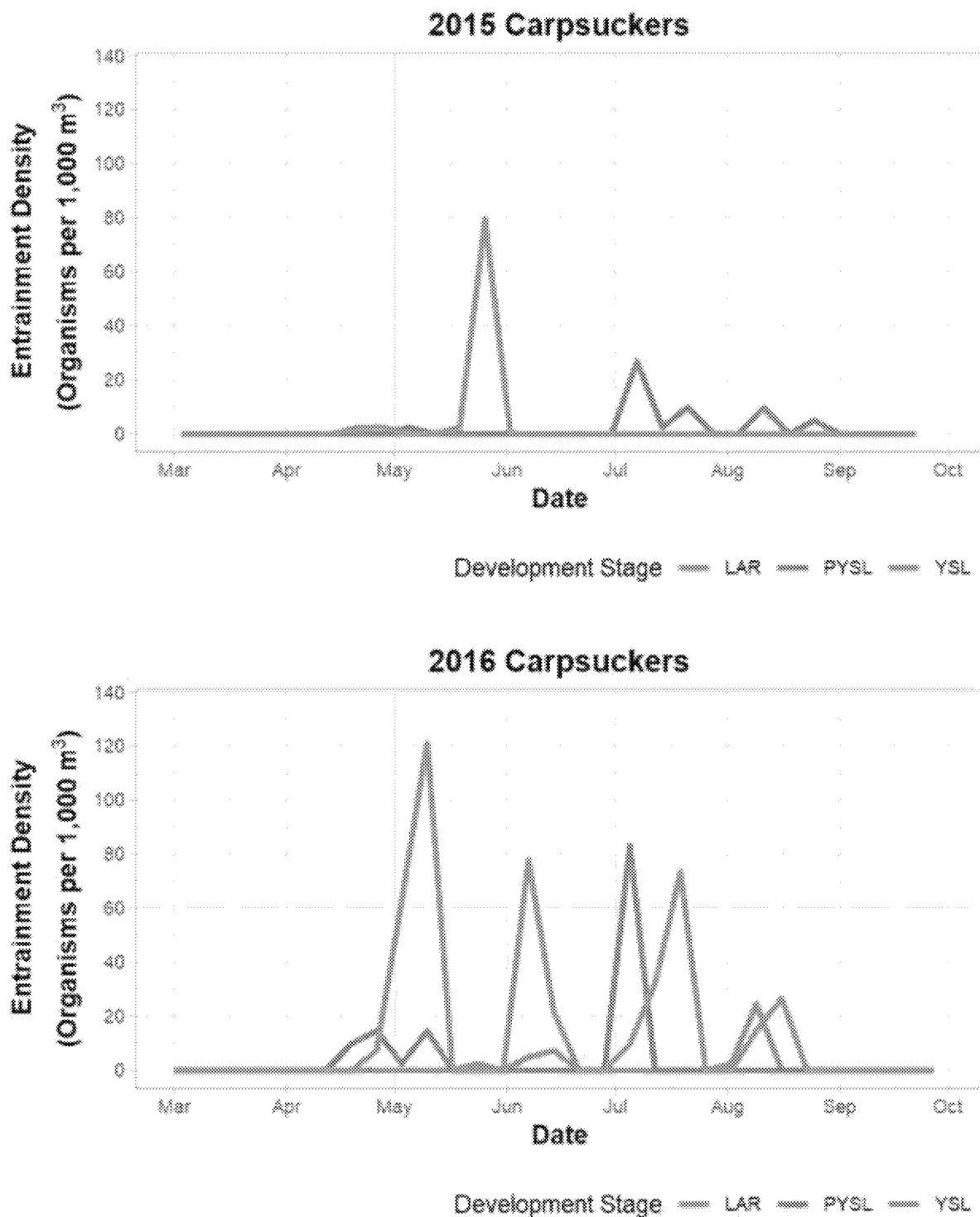


Figure 9 B-4 Seasonal Pattern of Entrainment of Carpsuckers (*Carpiodes* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

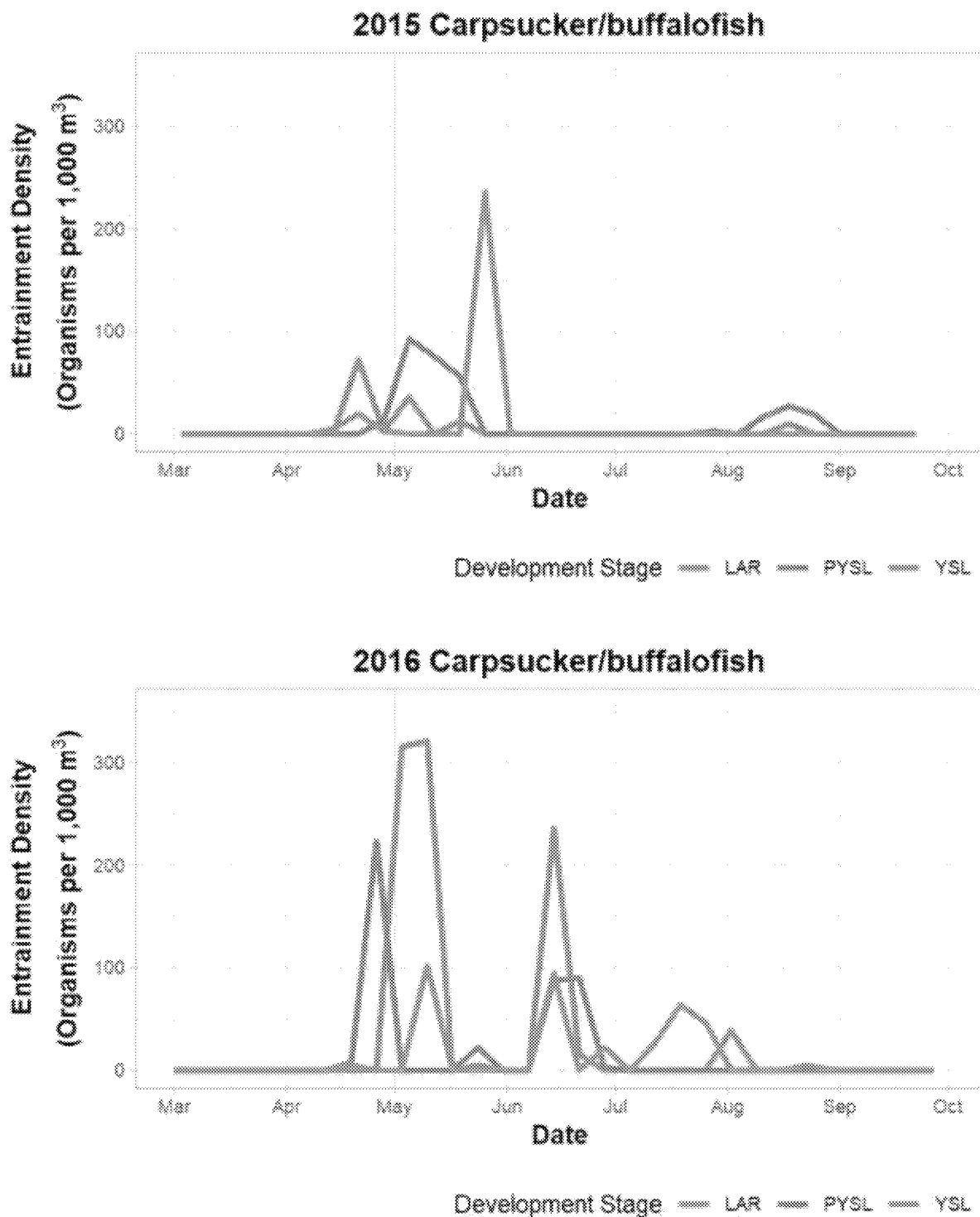
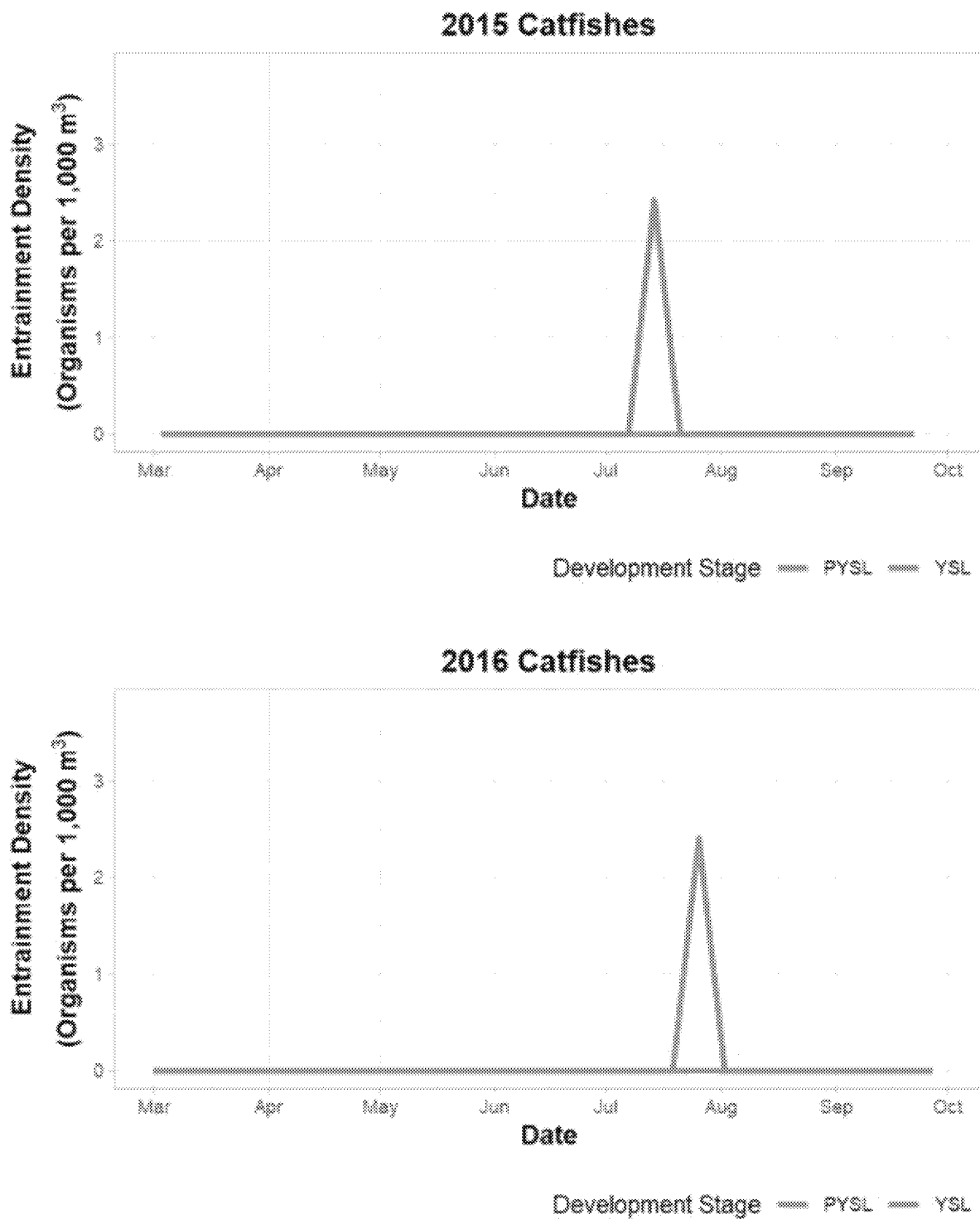


Figure 9 B-5 Seasonal Pattern of Entrainment of Carpsuckers and Buffalos (Subfamily Ictiobinae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-6 Seasonal Pattern of Entrainment of North American Catfishes (Family Ictaluridae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

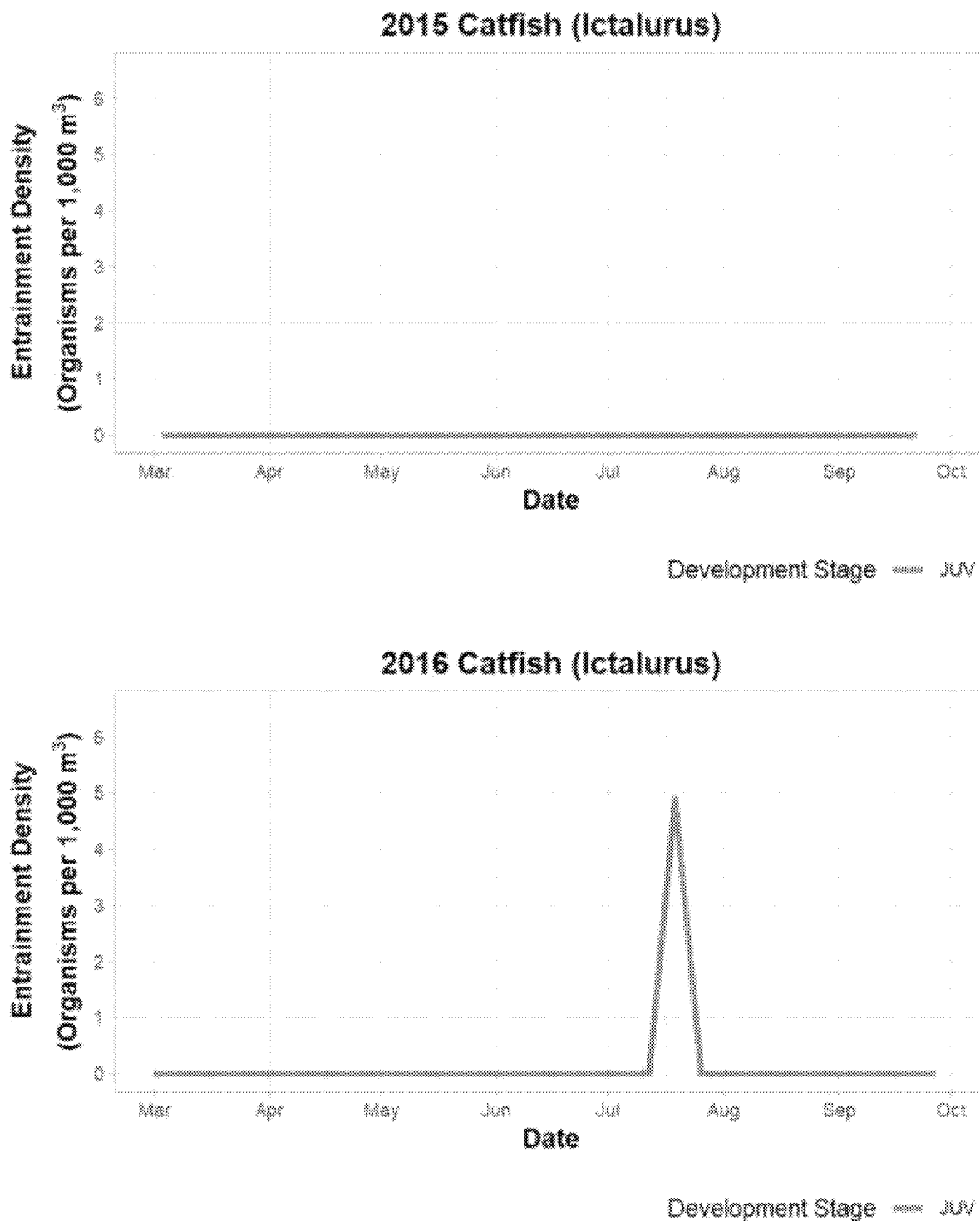


Figure 9 B-7 Seasonal Pattern of Entrainment of Catfishes (*Ictalurus* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

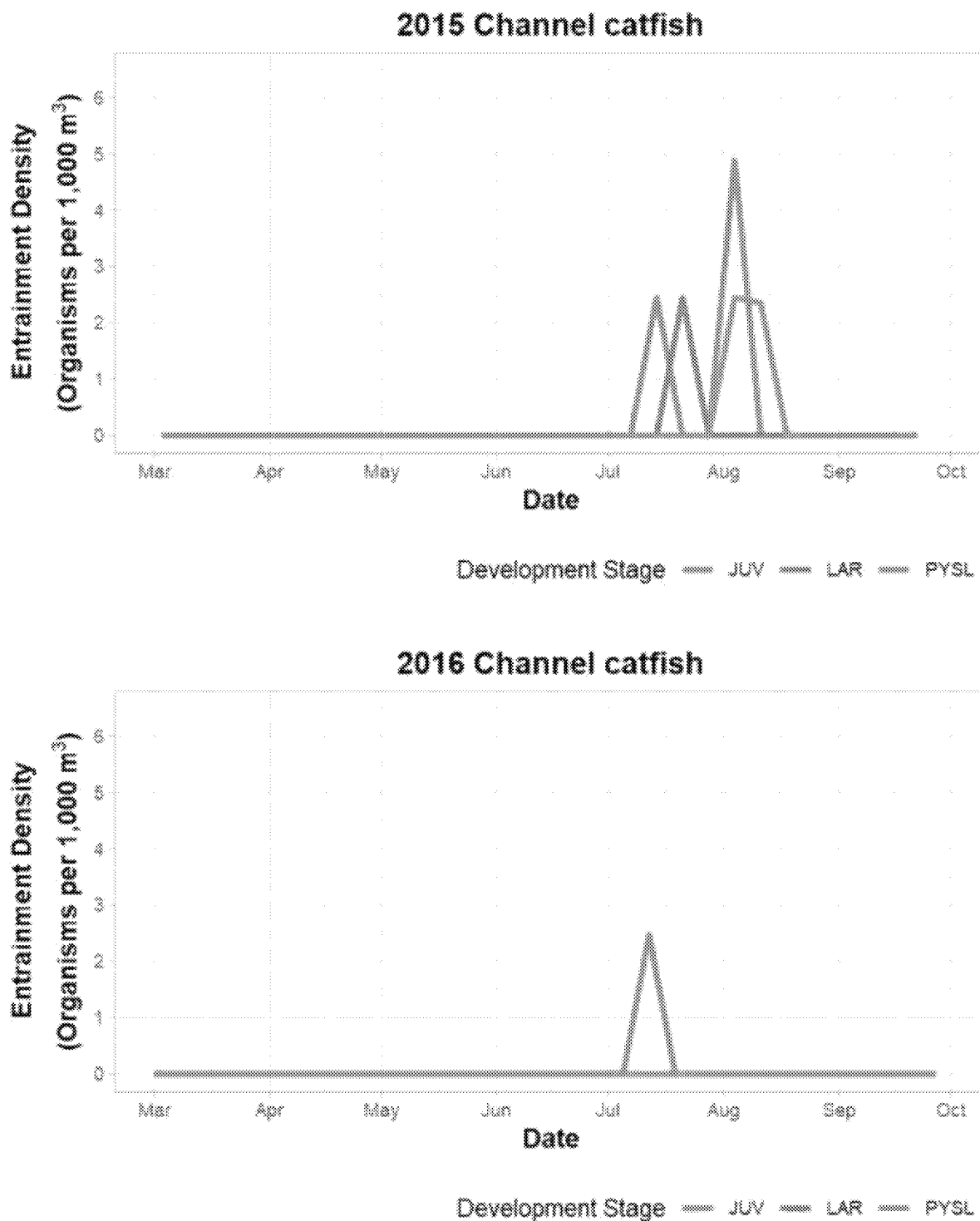
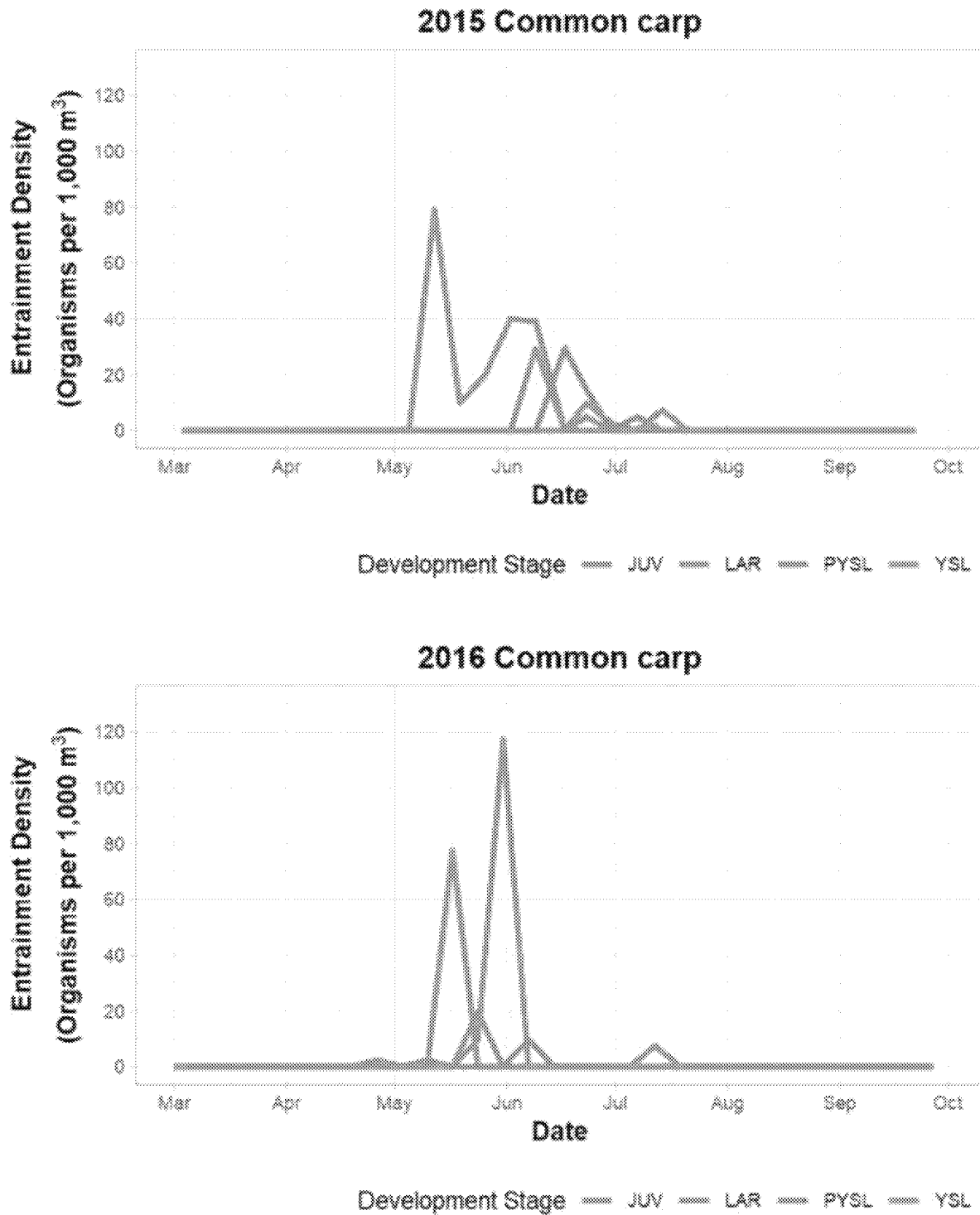


Figure 9 B-8 Seasonal Pattern of Entrainment of Channel Catfish by Development Stages  
Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-9 Seasonal Pattern of Entrainment of Common Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



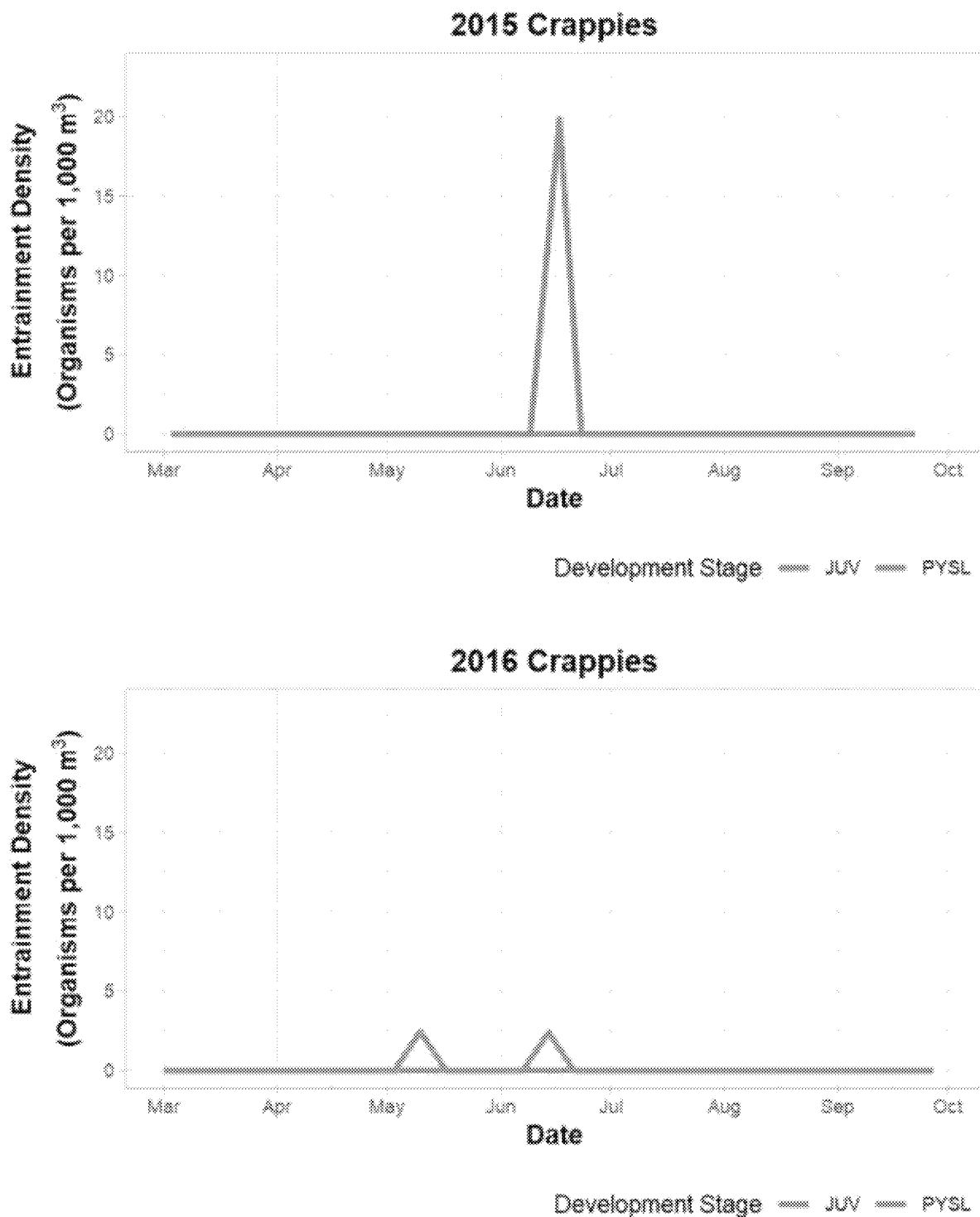


Figure 9 B-10 Seasonal Pattern of Entrainment of Crappies (*Pomoxis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

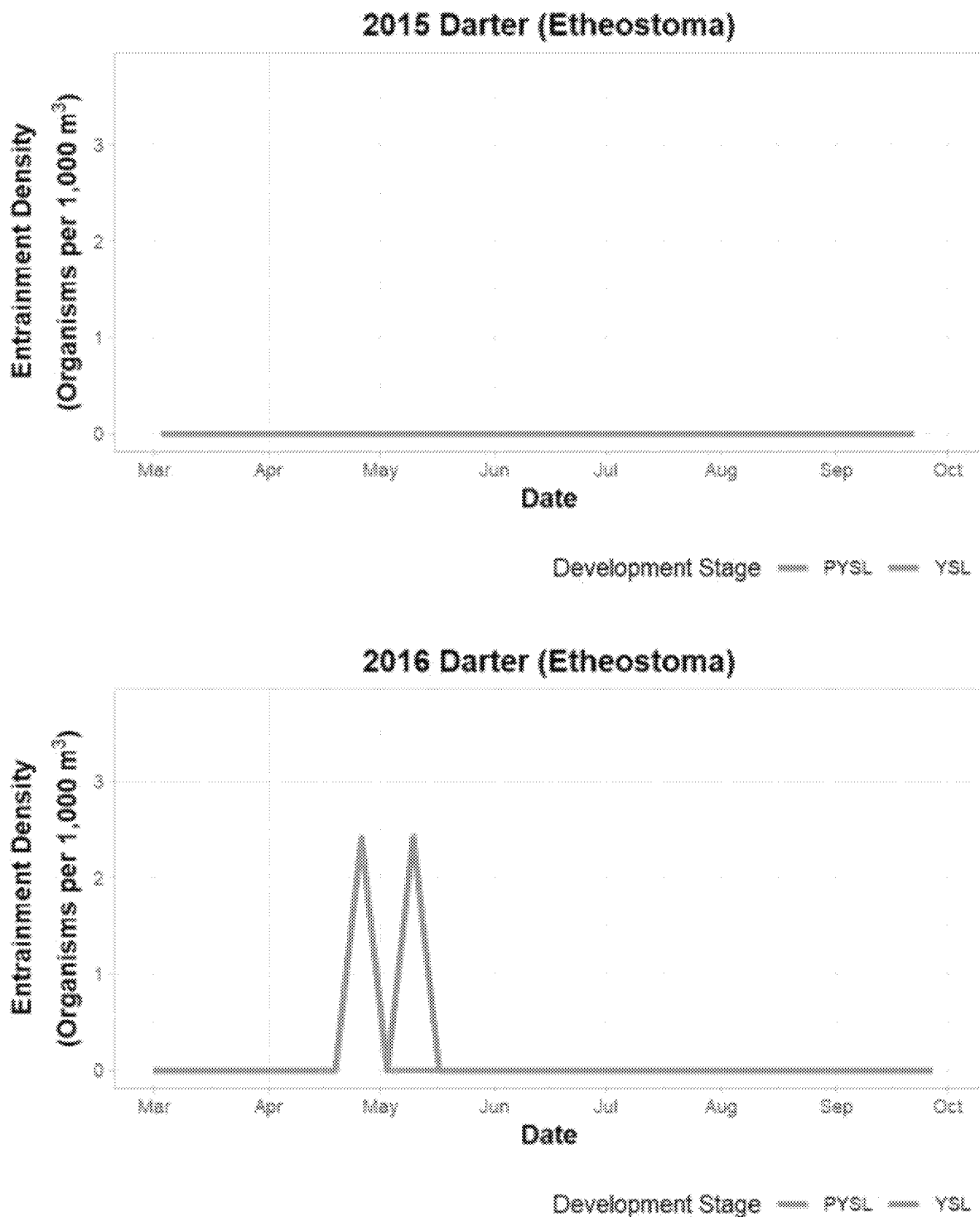


Figure 9 B-11 Seasonal Pattern of Entrainment of Darters (*Etheostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

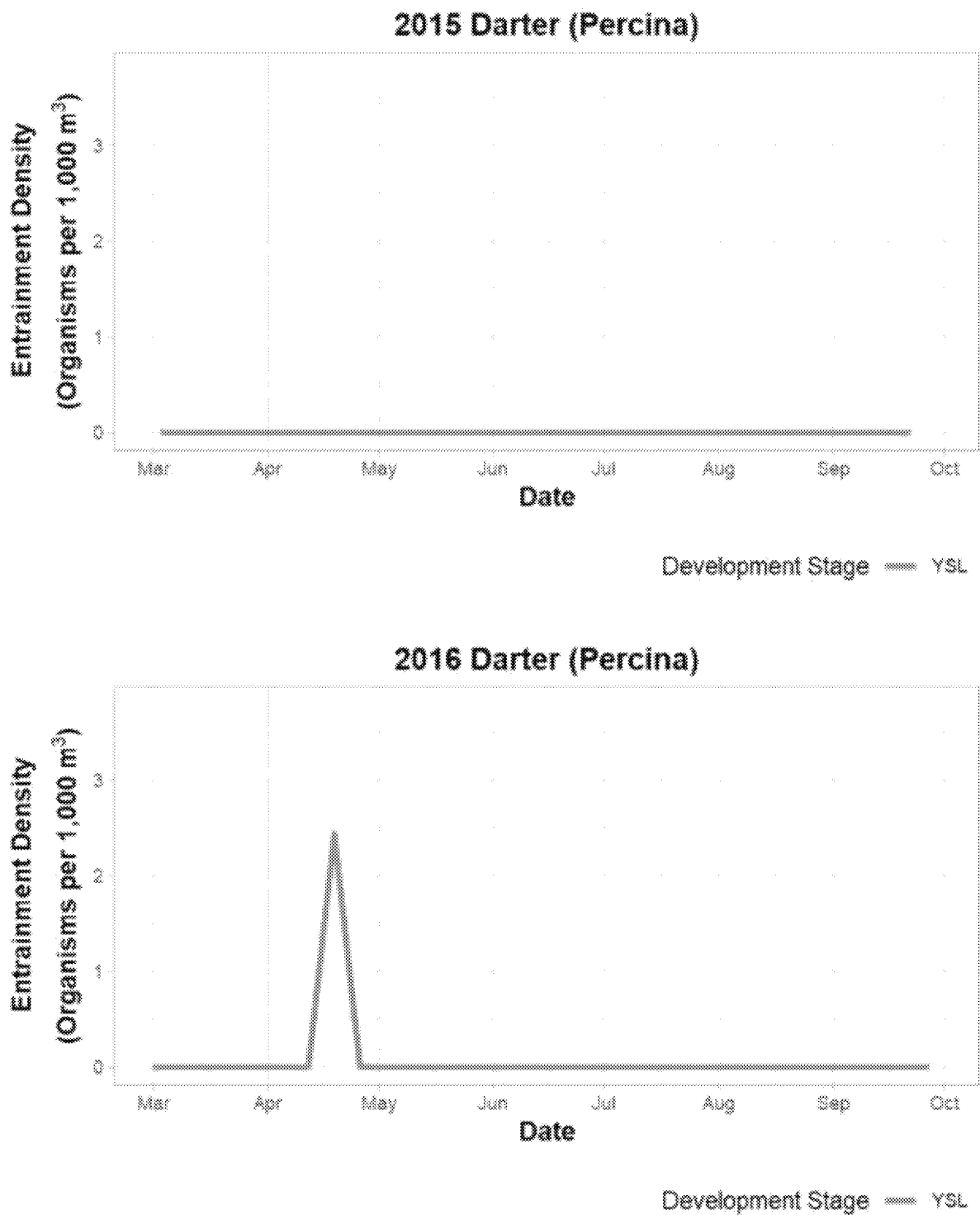
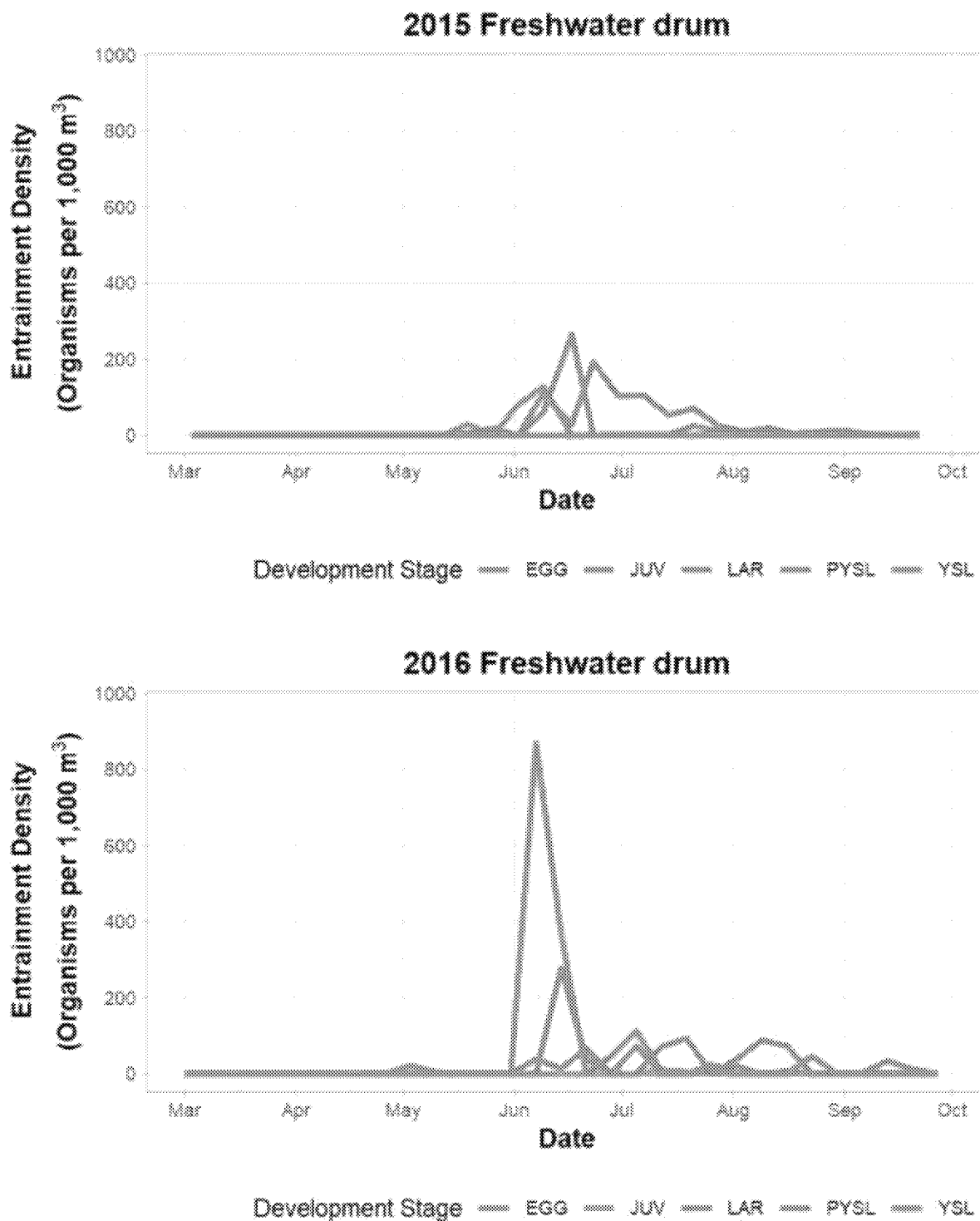
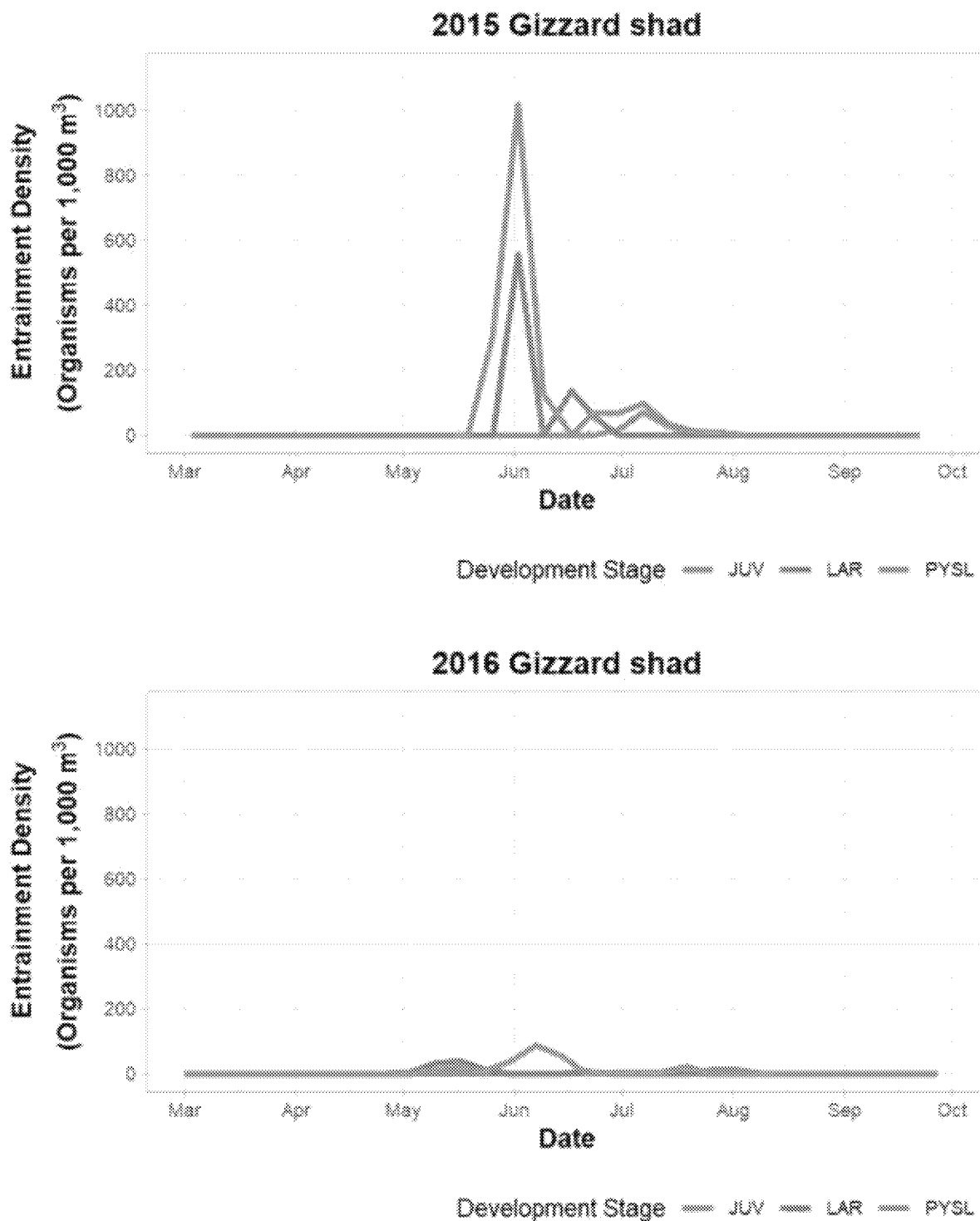


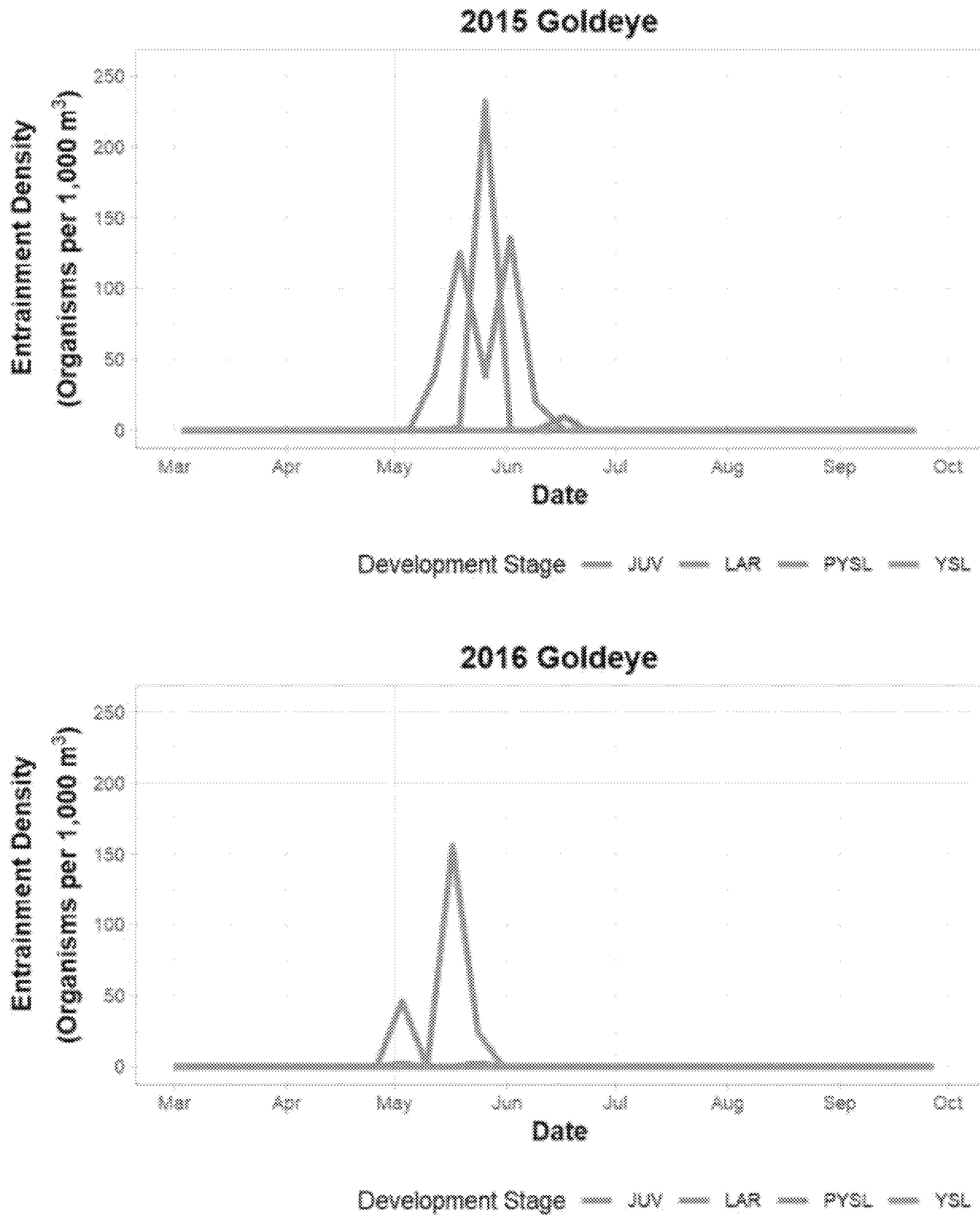
Figure 9 B-12 Seasonal Pattern of Entrainment of Darters (*Percina* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-13 Seasonal Pattern of Entrainment of Freshwater Drum by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-14 Seasonal Pattern of Entrainment of Gizzard Shad by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-15 Seasonal Pattern of Entrainment of Goldeye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

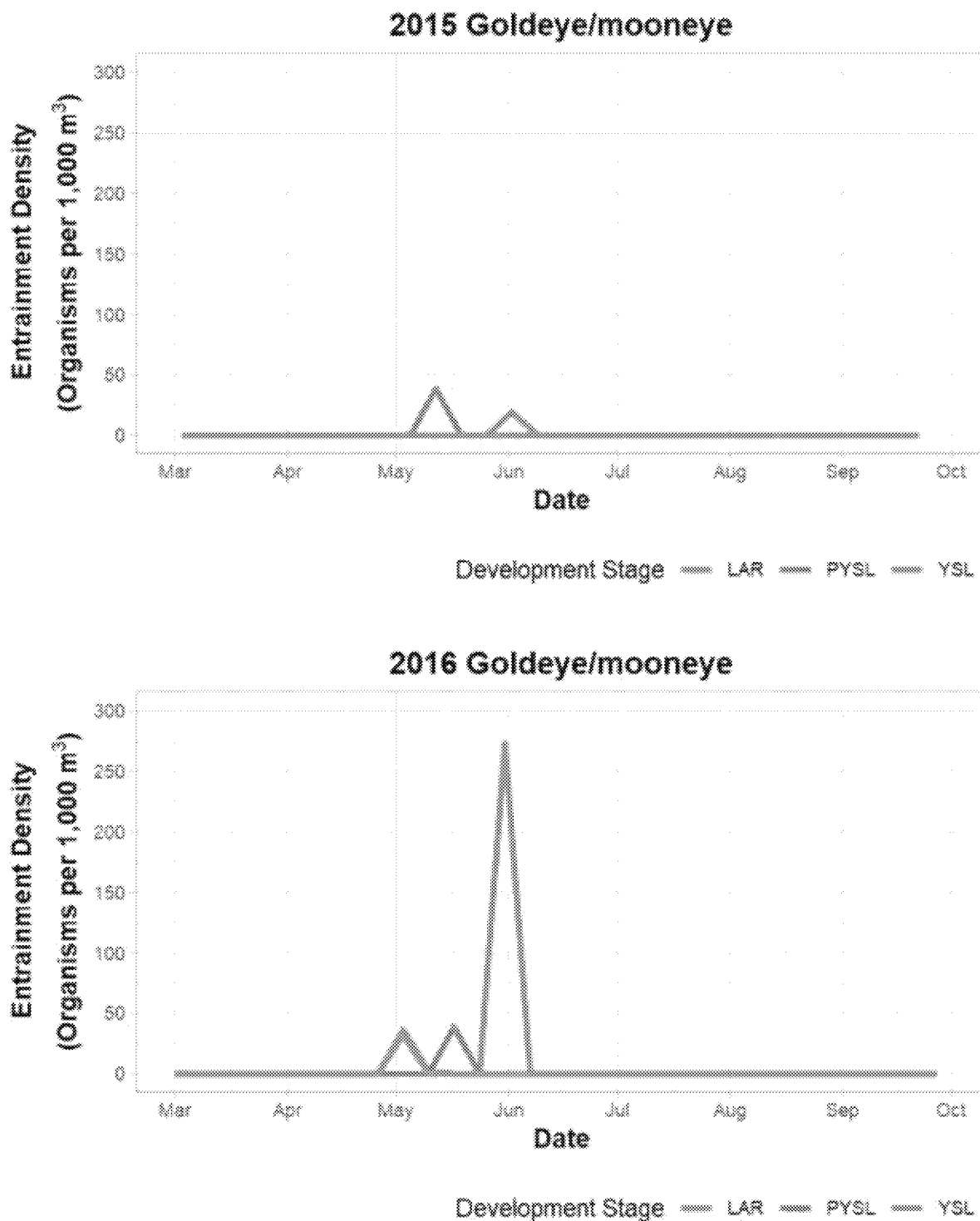


Figure 9 B-16 Seasonal Pattern of Entrainment of Mooneyes (*Hiodon* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

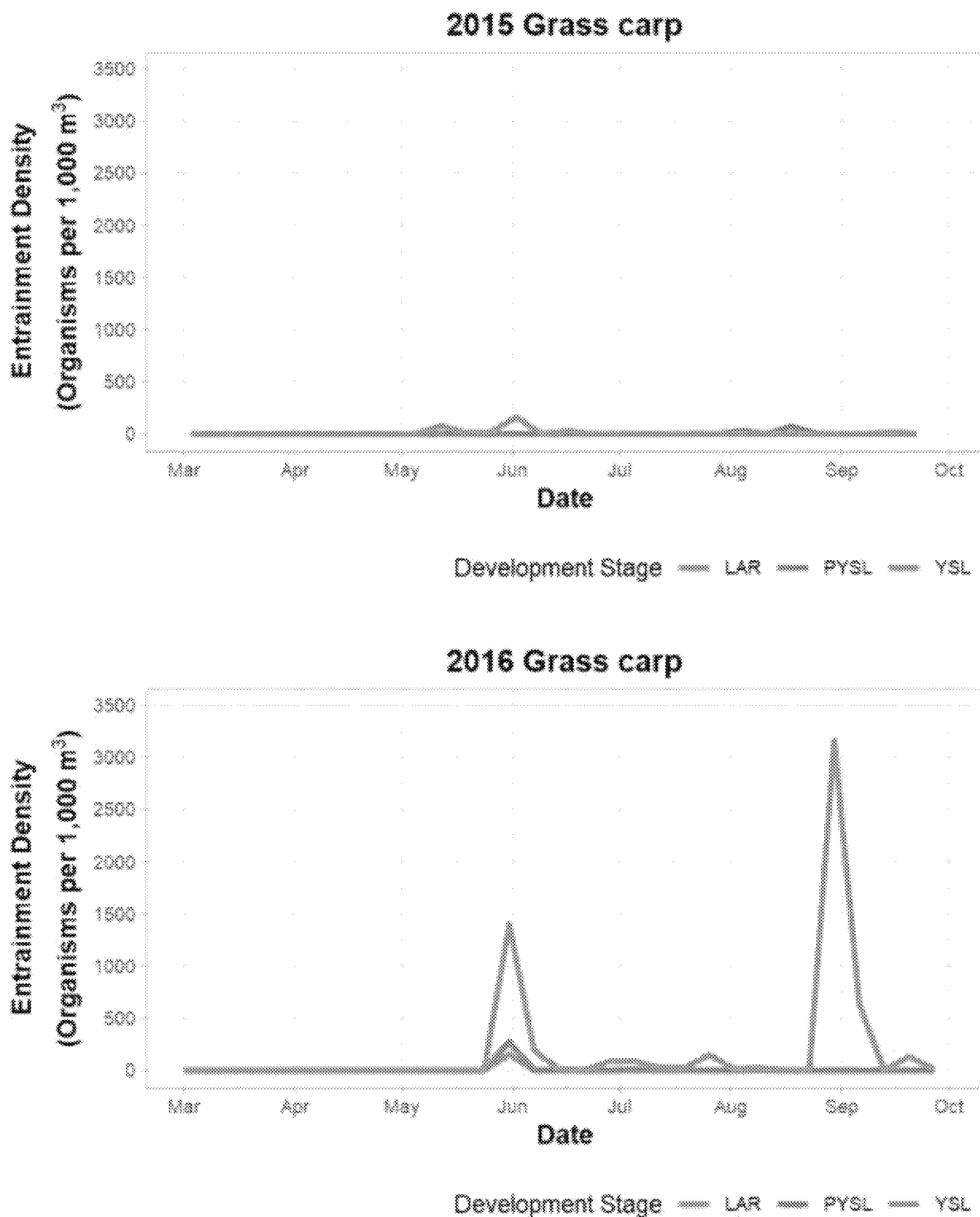


Figure 9 B-17 Seasonal Pattern of Entrainment of Grass Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



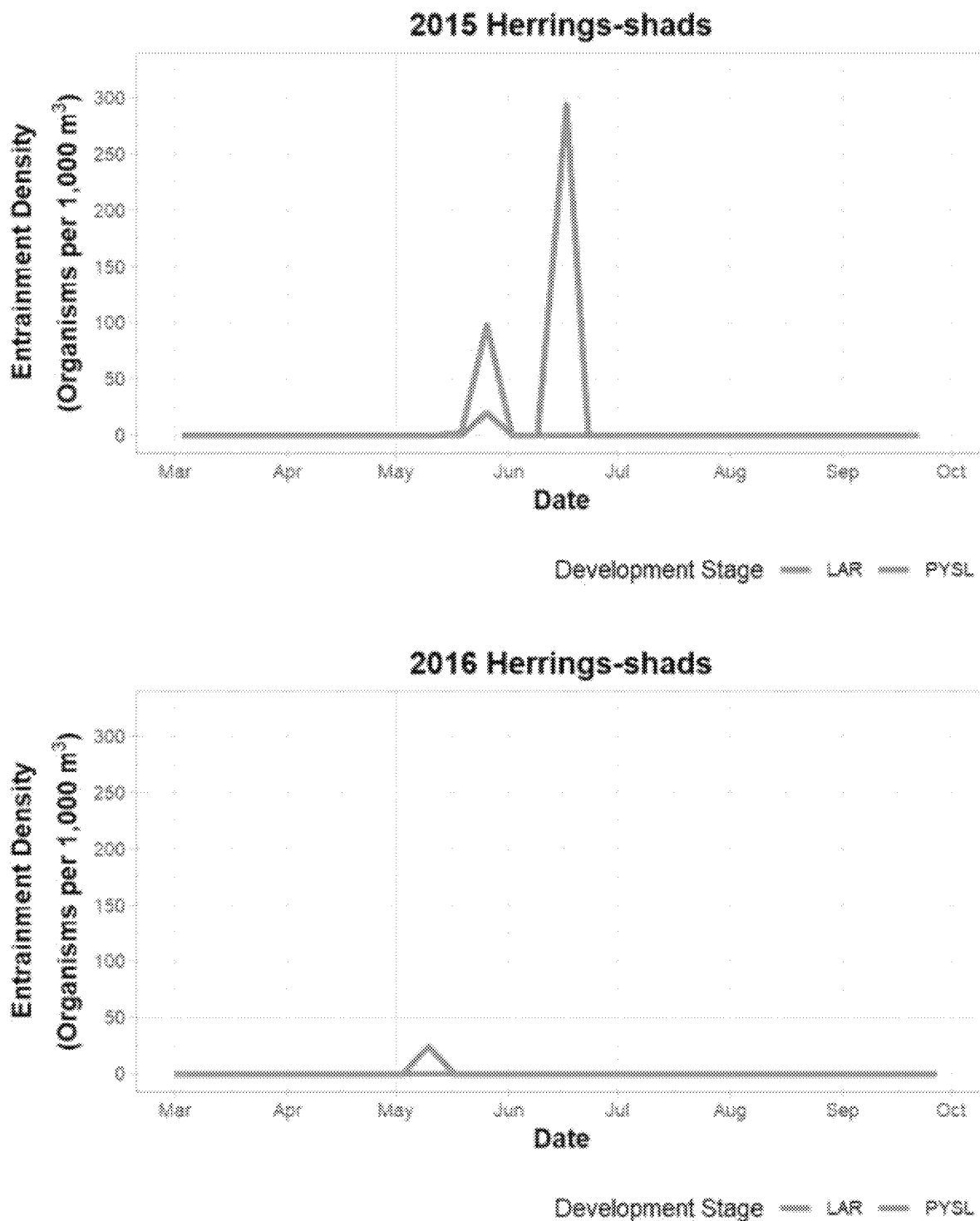


Figure 9 B-18 Seasonal Pattern of Entrainment of Shads (*Dorosoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

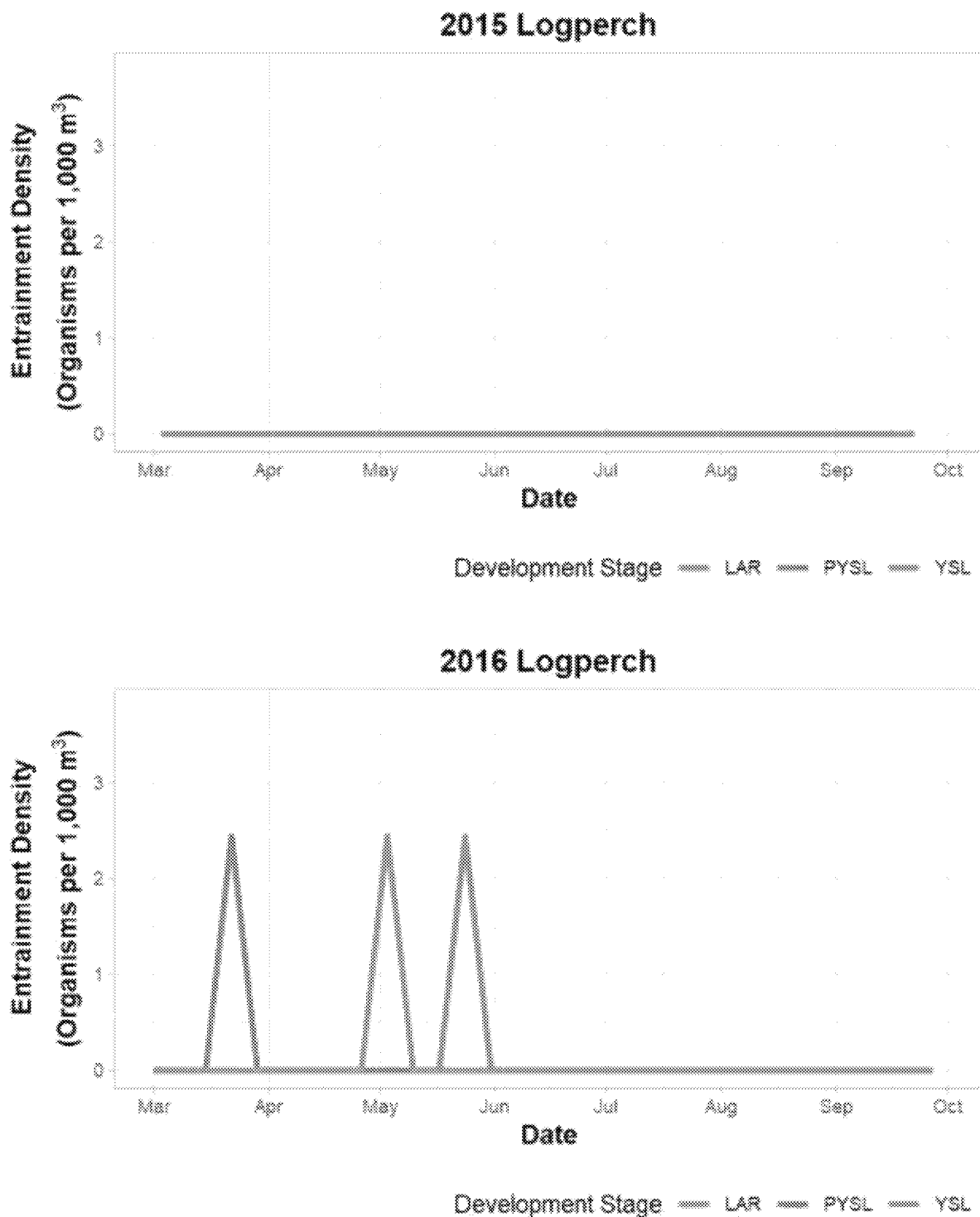


Figure 9 B-19 Seasonal Pattern of Entrainment of Logperch by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

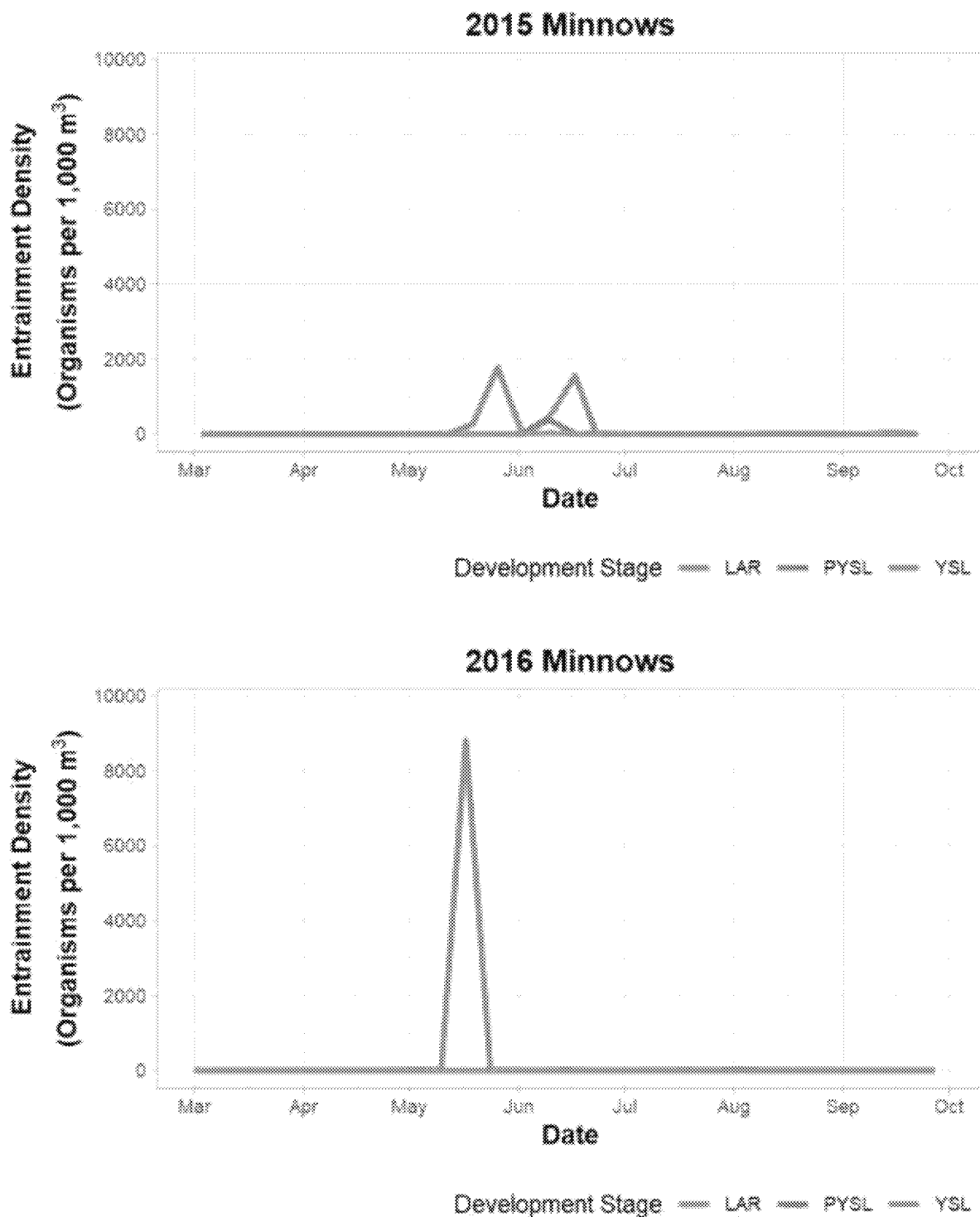
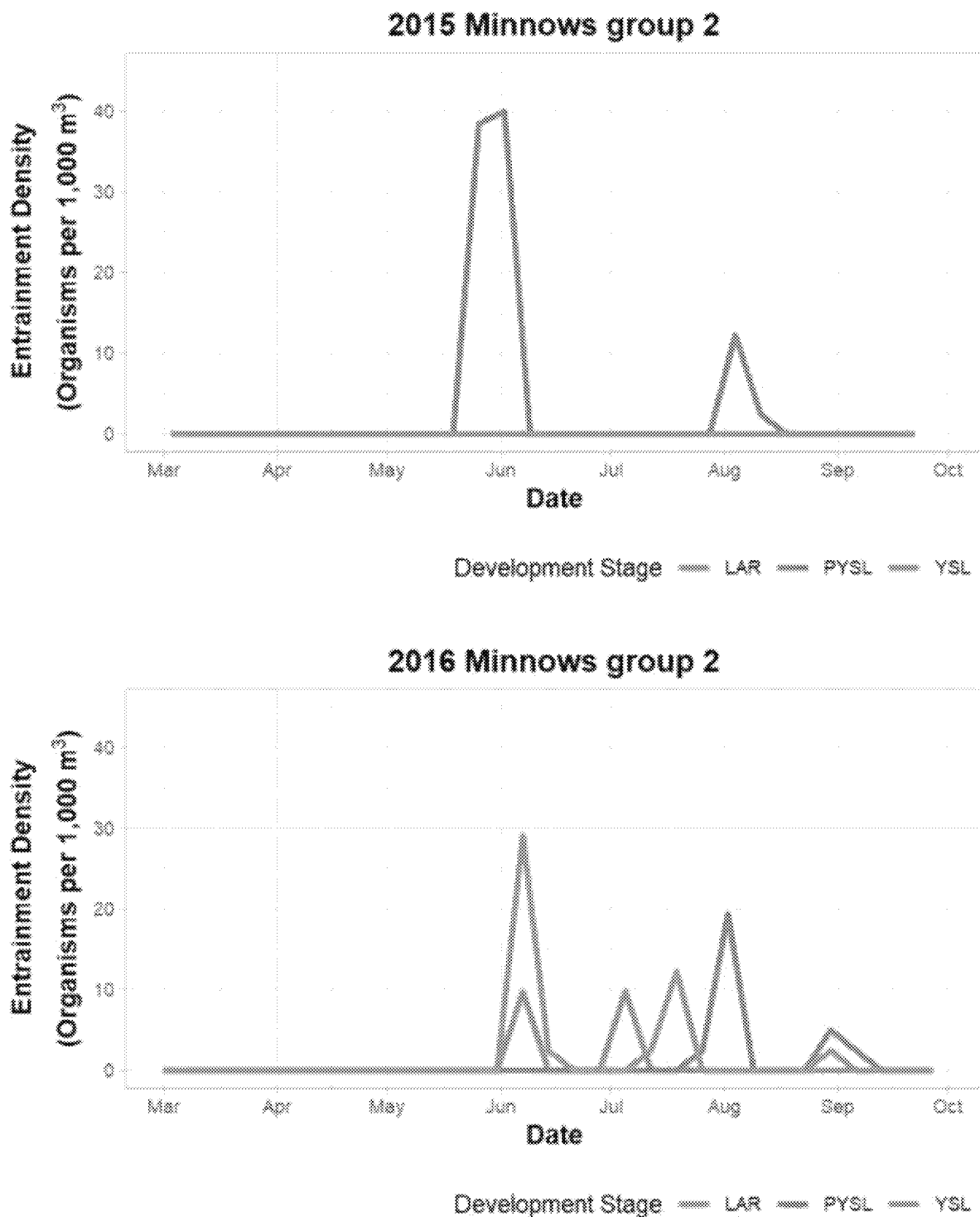


Figure 9 B-20 Seasonal Pattern of Entrainment of Minnow Family (Cyprinidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-21 Seasonal Pattern of Entrainment of Minnow Group 2 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

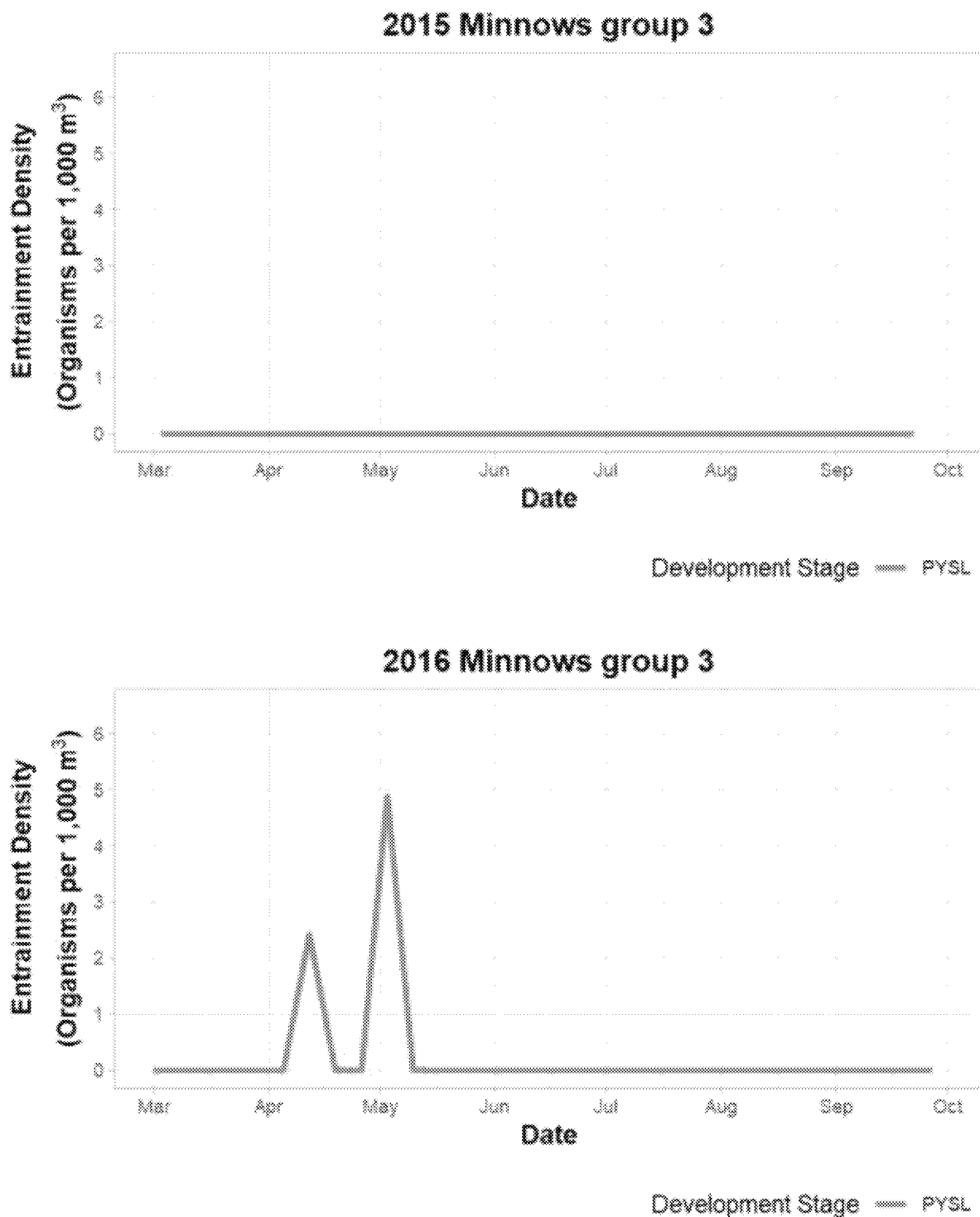
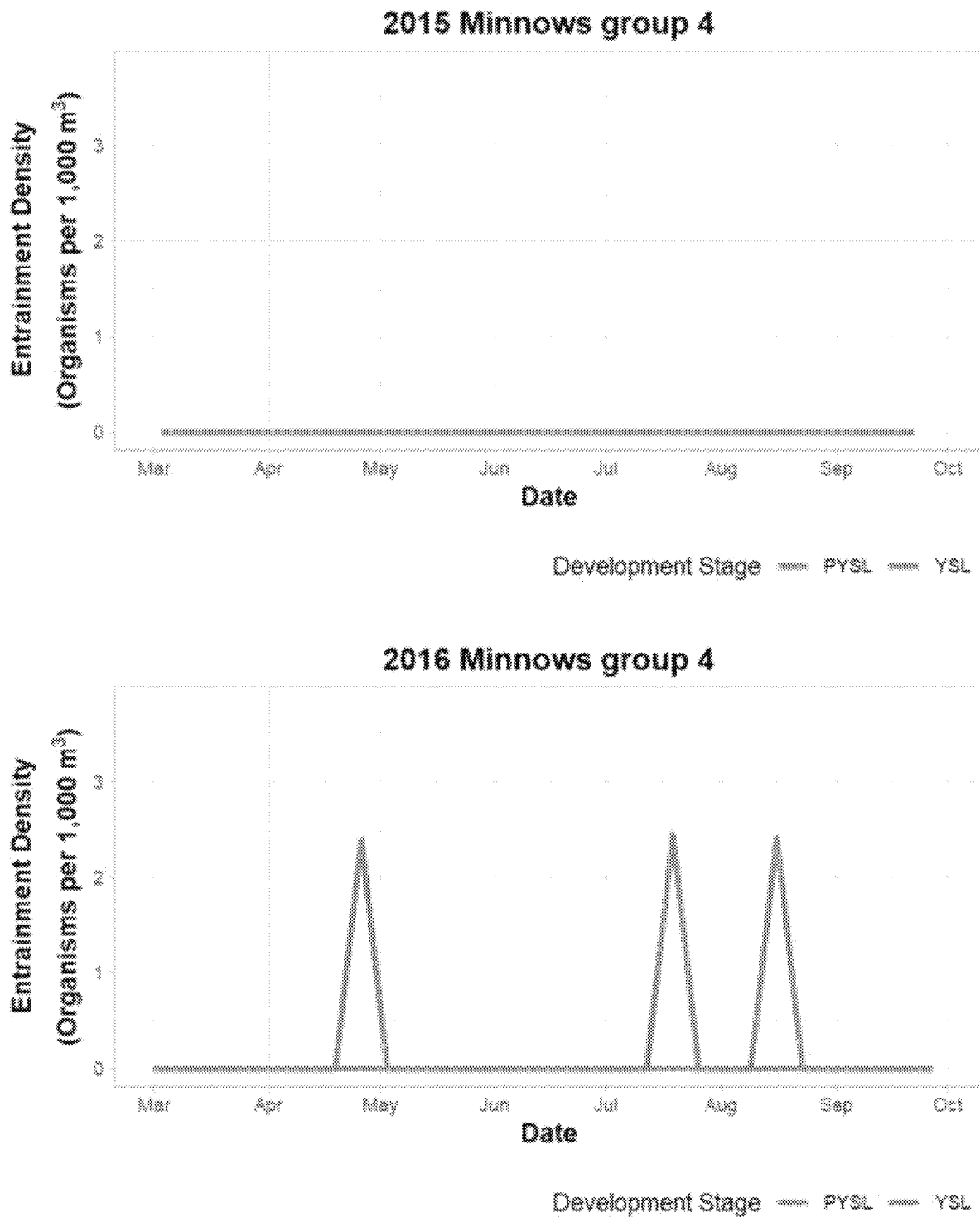


Figure 9 B-22 Seasonal Pattern of Entrainment of Minnow Group 3 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-23 Seasonal Pattern of Entrainment of Minnow Group 4 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

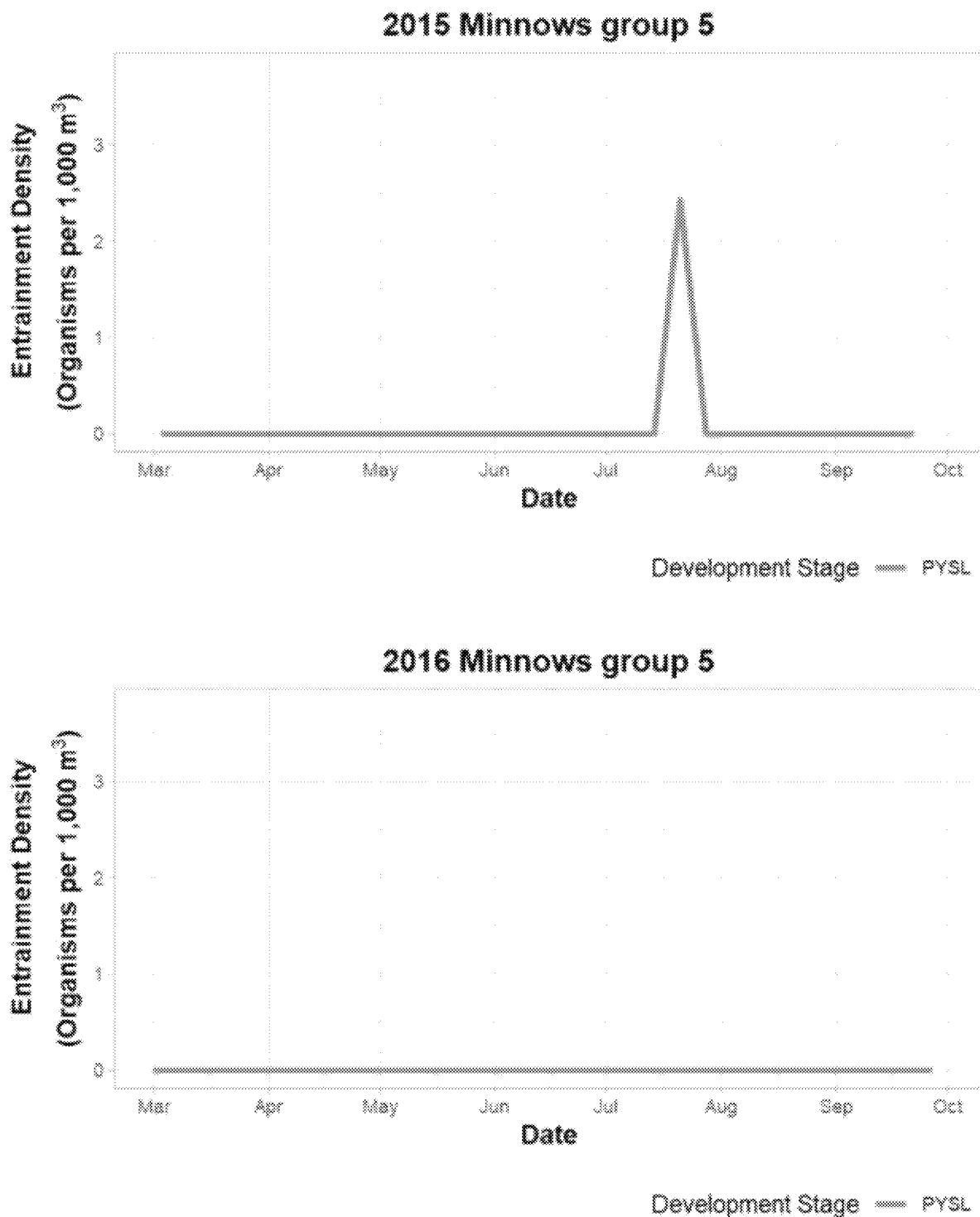


Figure 9 B-24 Seasonal Pattern of Entrainment of Minnow Group 5 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

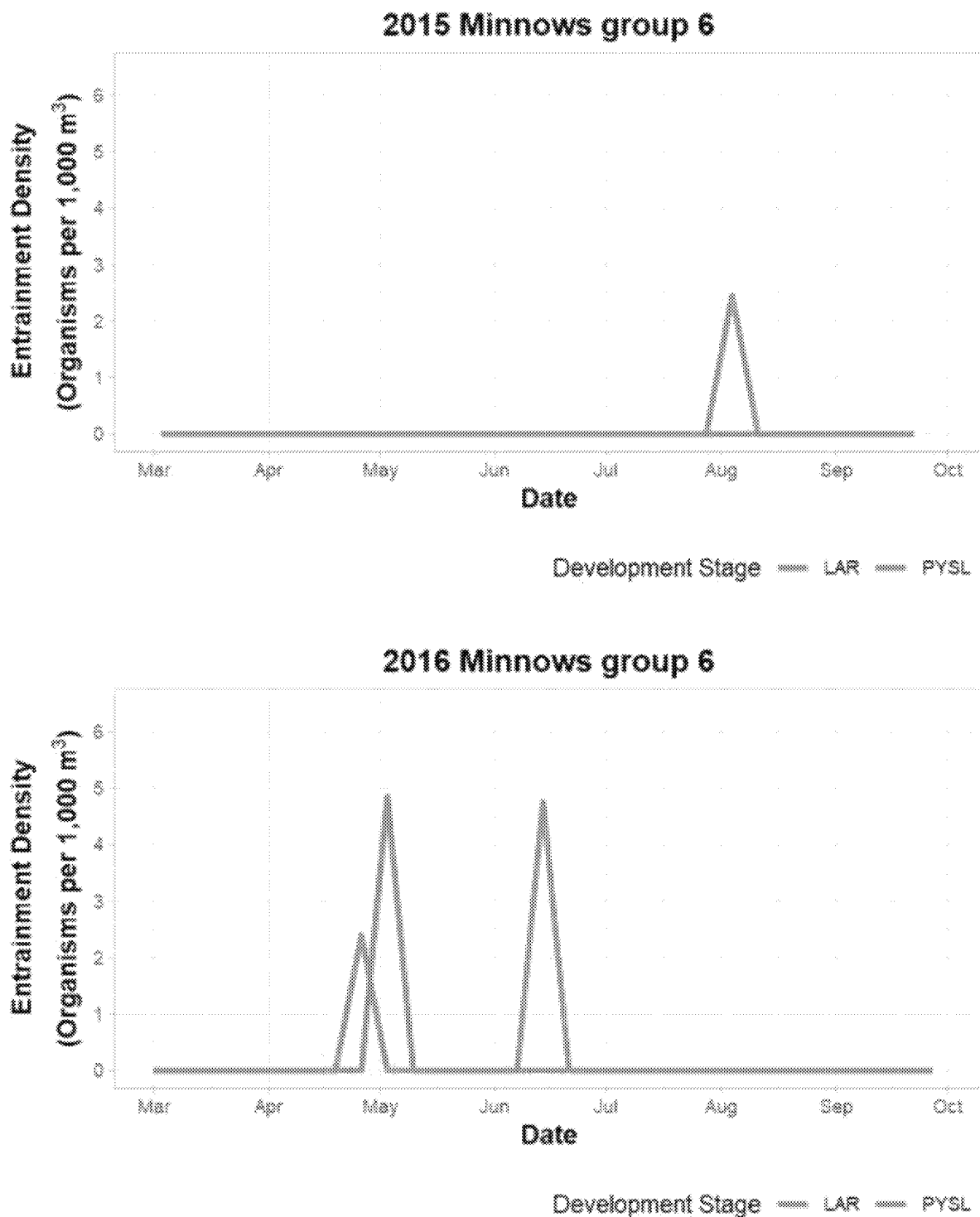
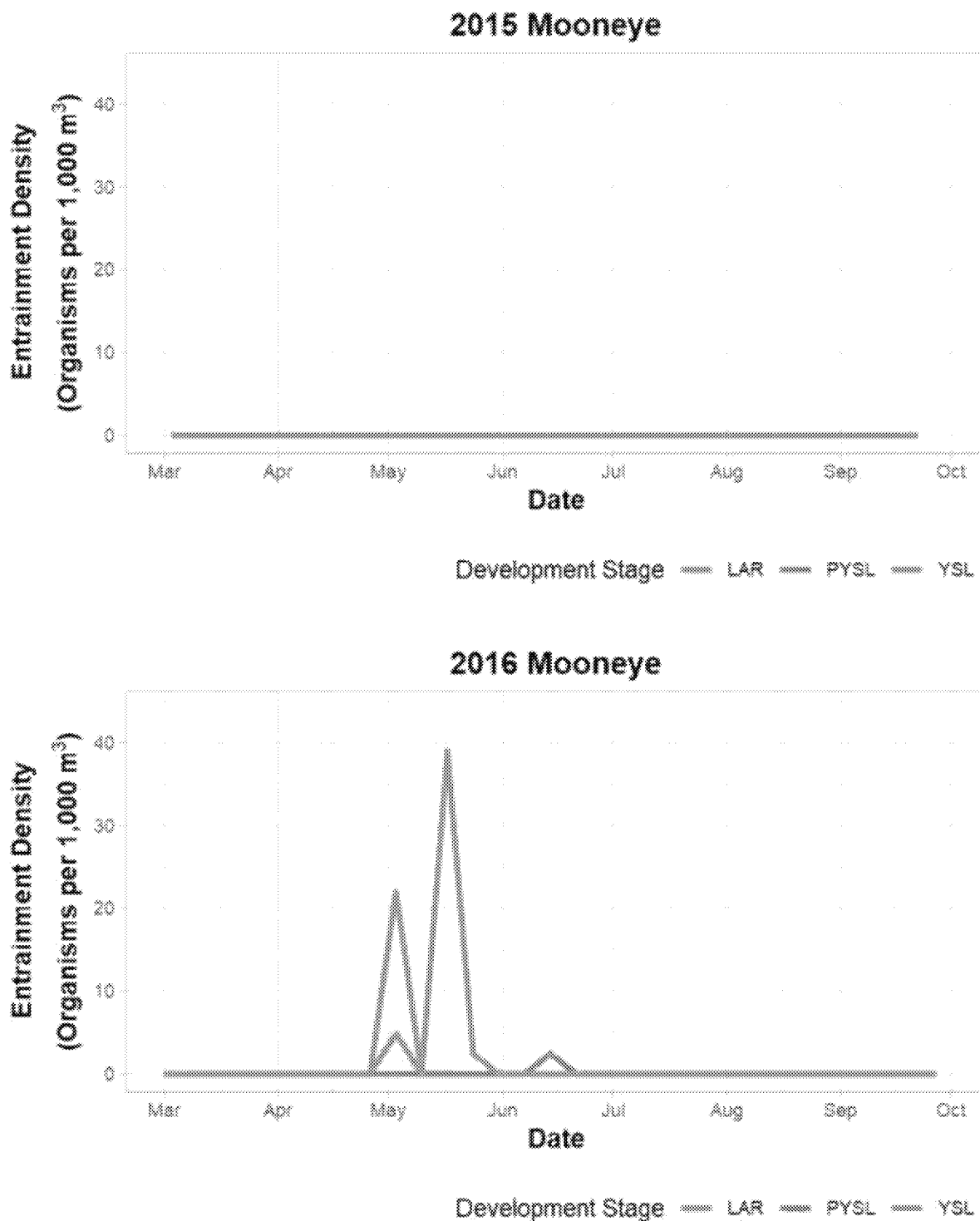
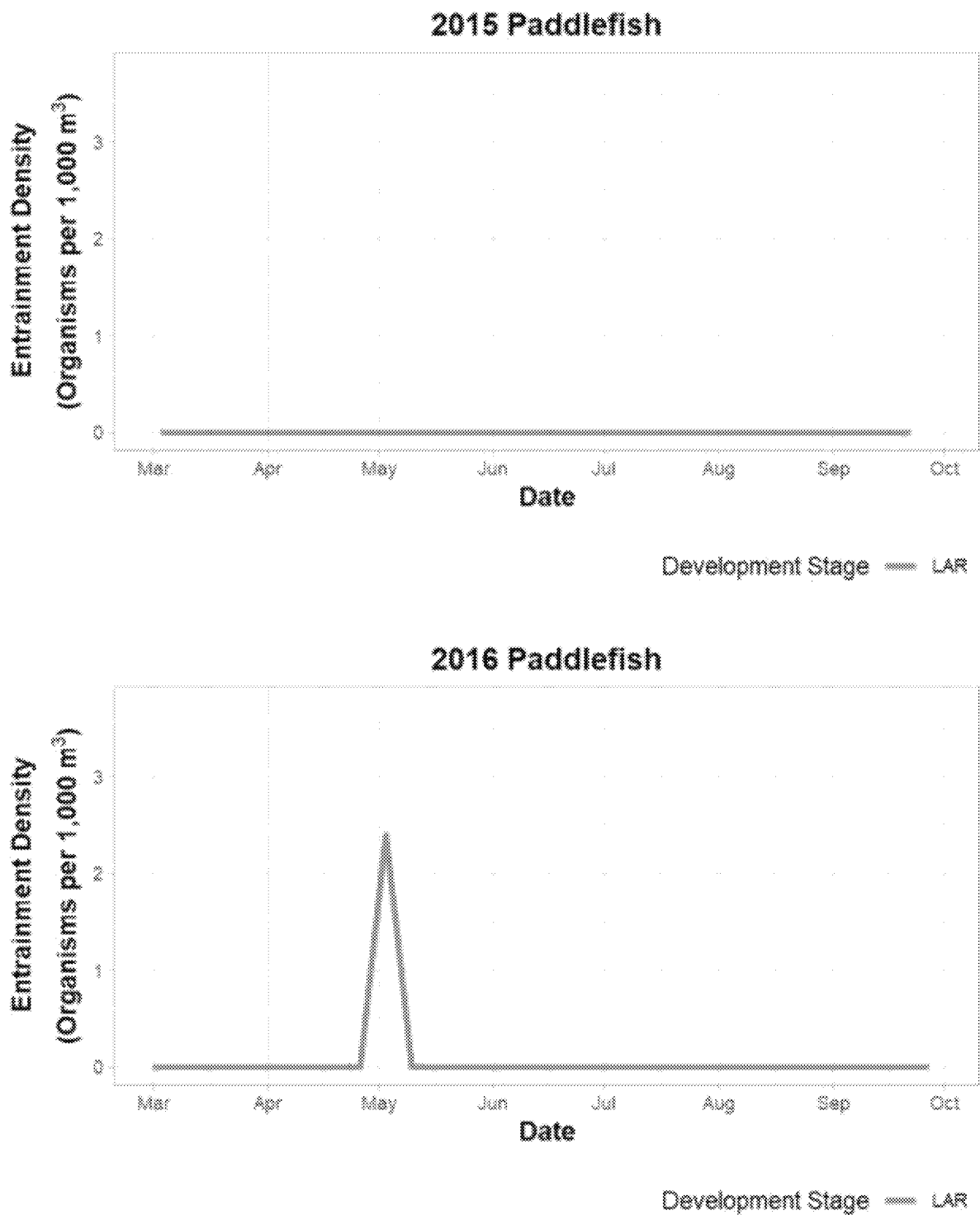


Figure 9 B-25 Seasonal Pattern of Entrainment of Minnow Group 6 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.





**Figure 9 B-26 Seasonal Pattern of Entrainment of Mooneye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-27 Seasonal Pattern of Entrainment of Paddlefish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

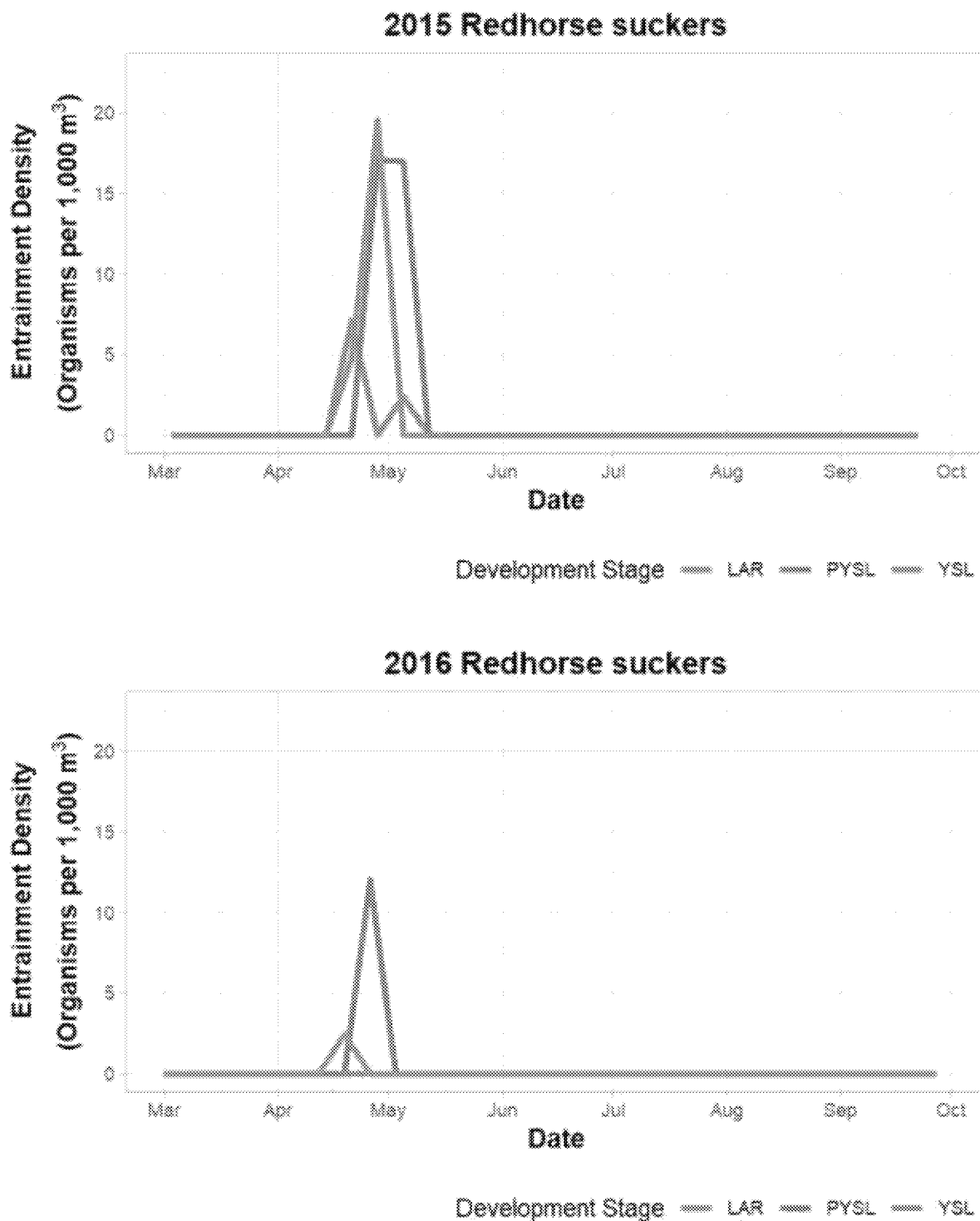
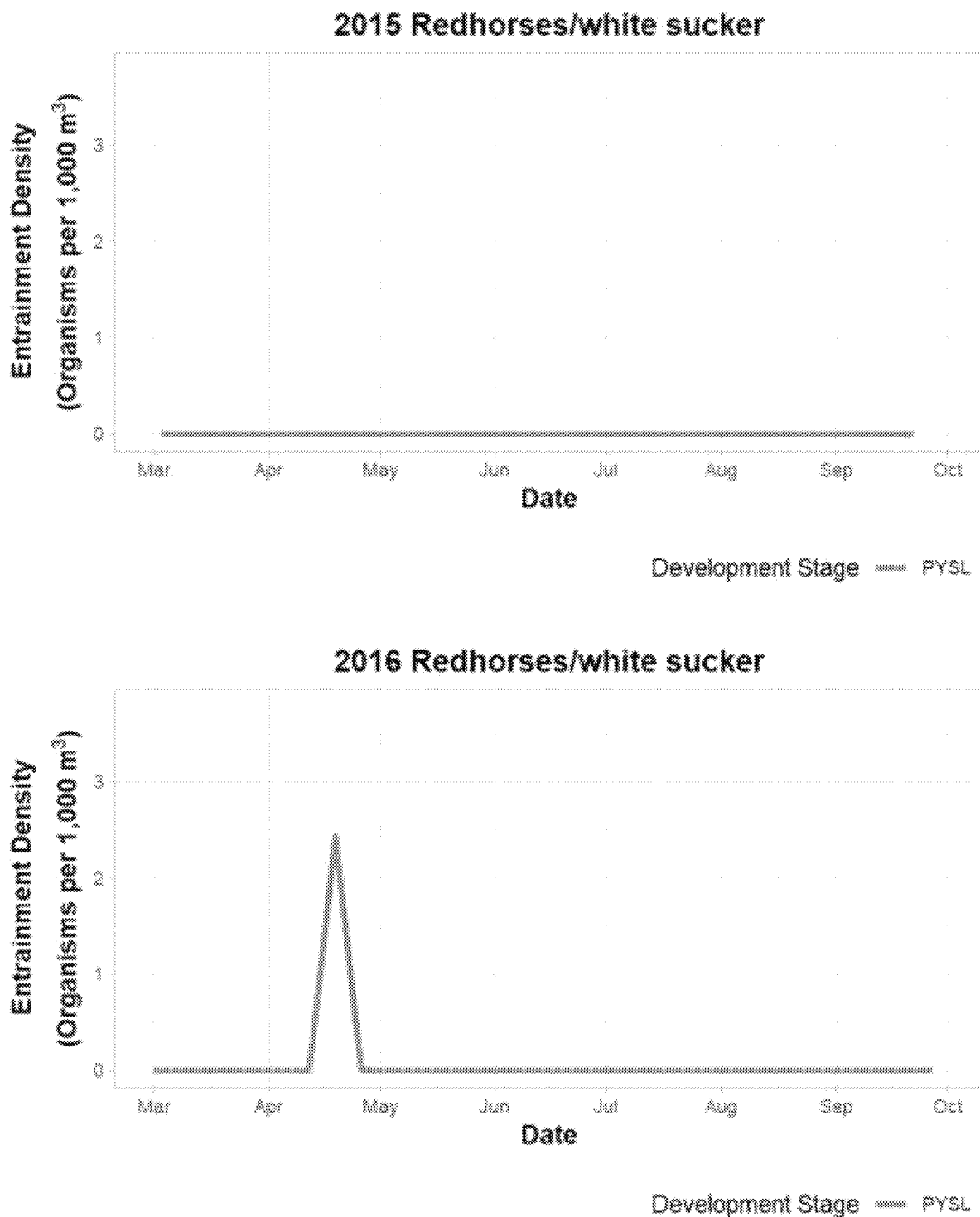
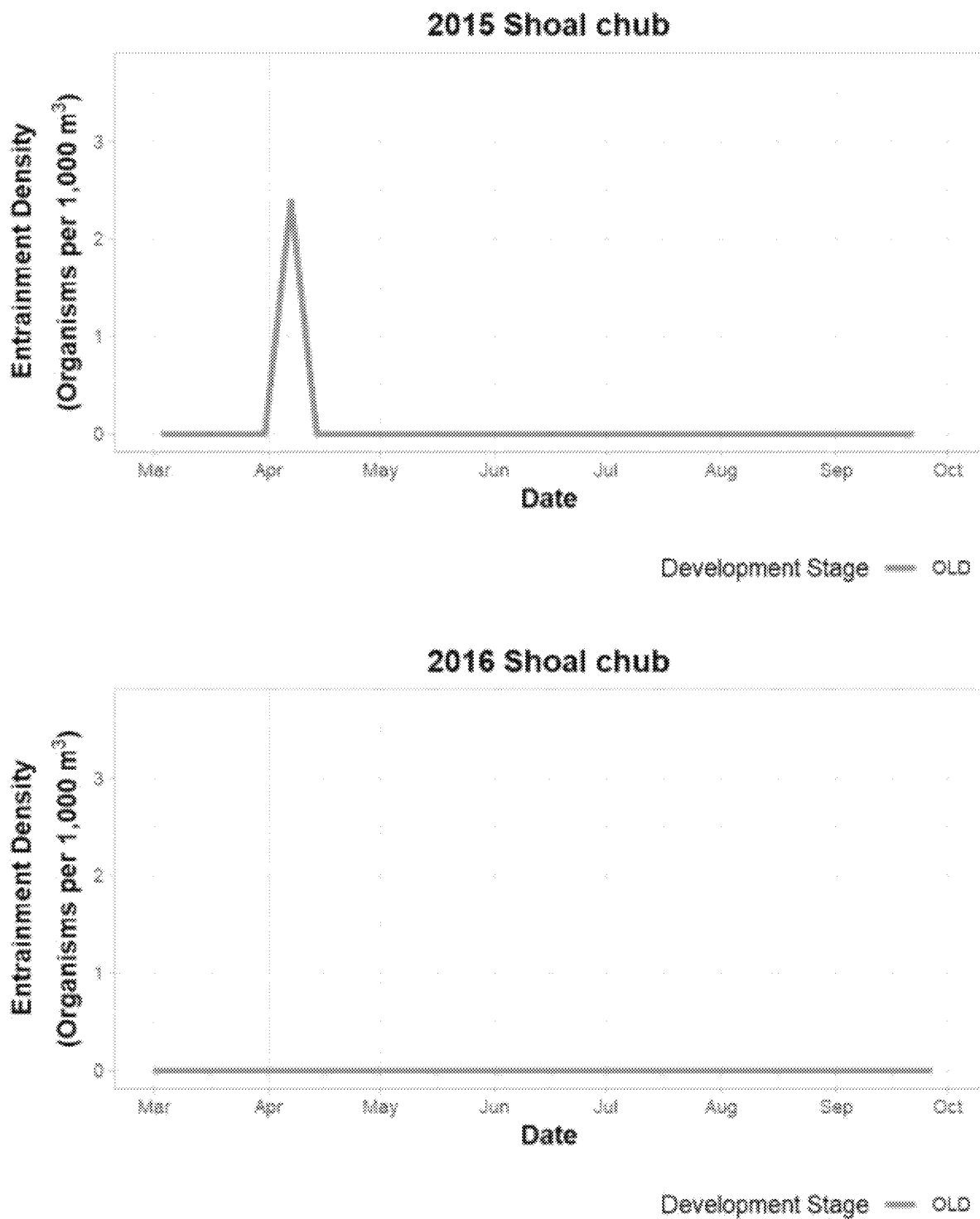


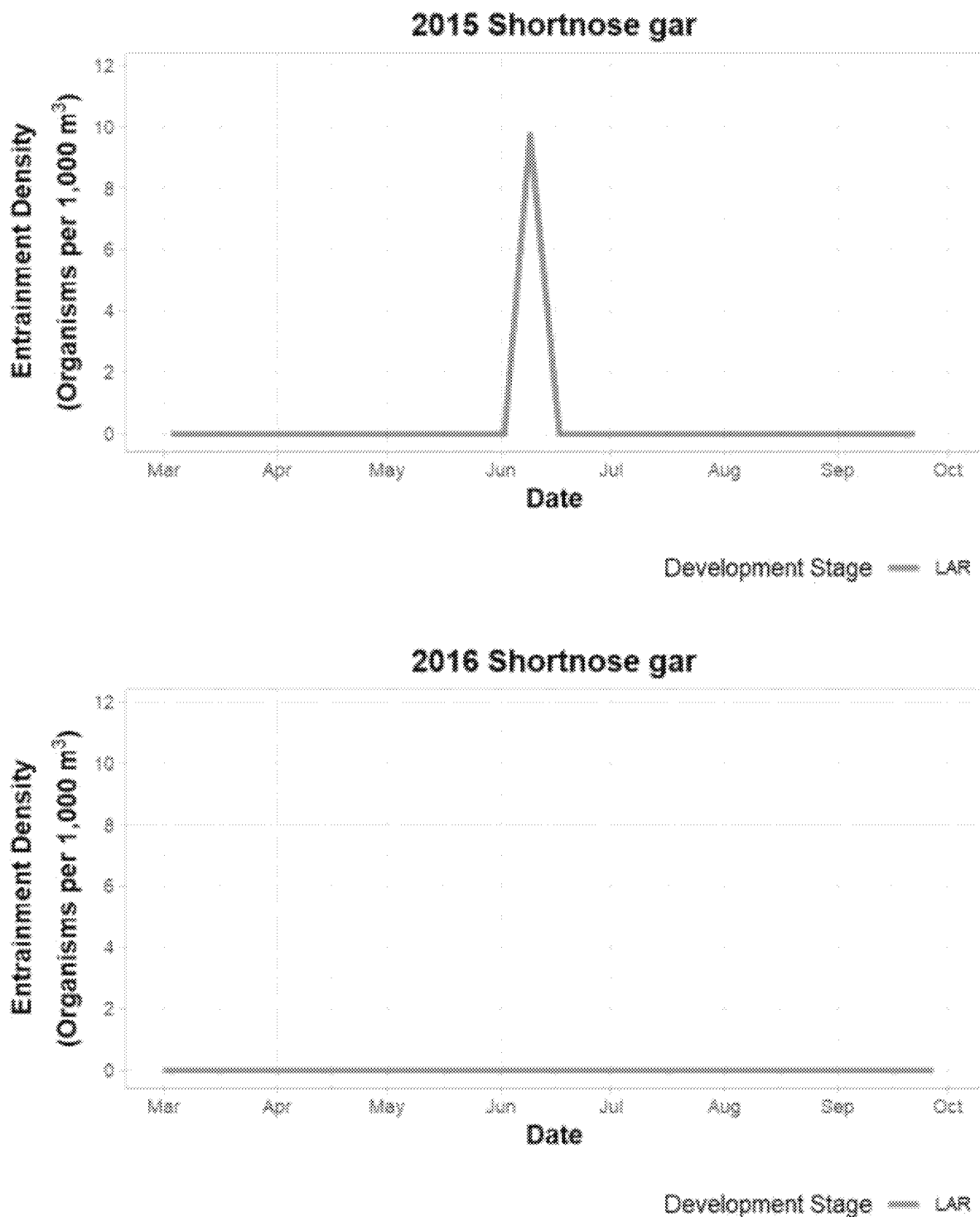
Figure 9 B-28 Seasonal Pattern of Entrainment of Redhorses (*Moxostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



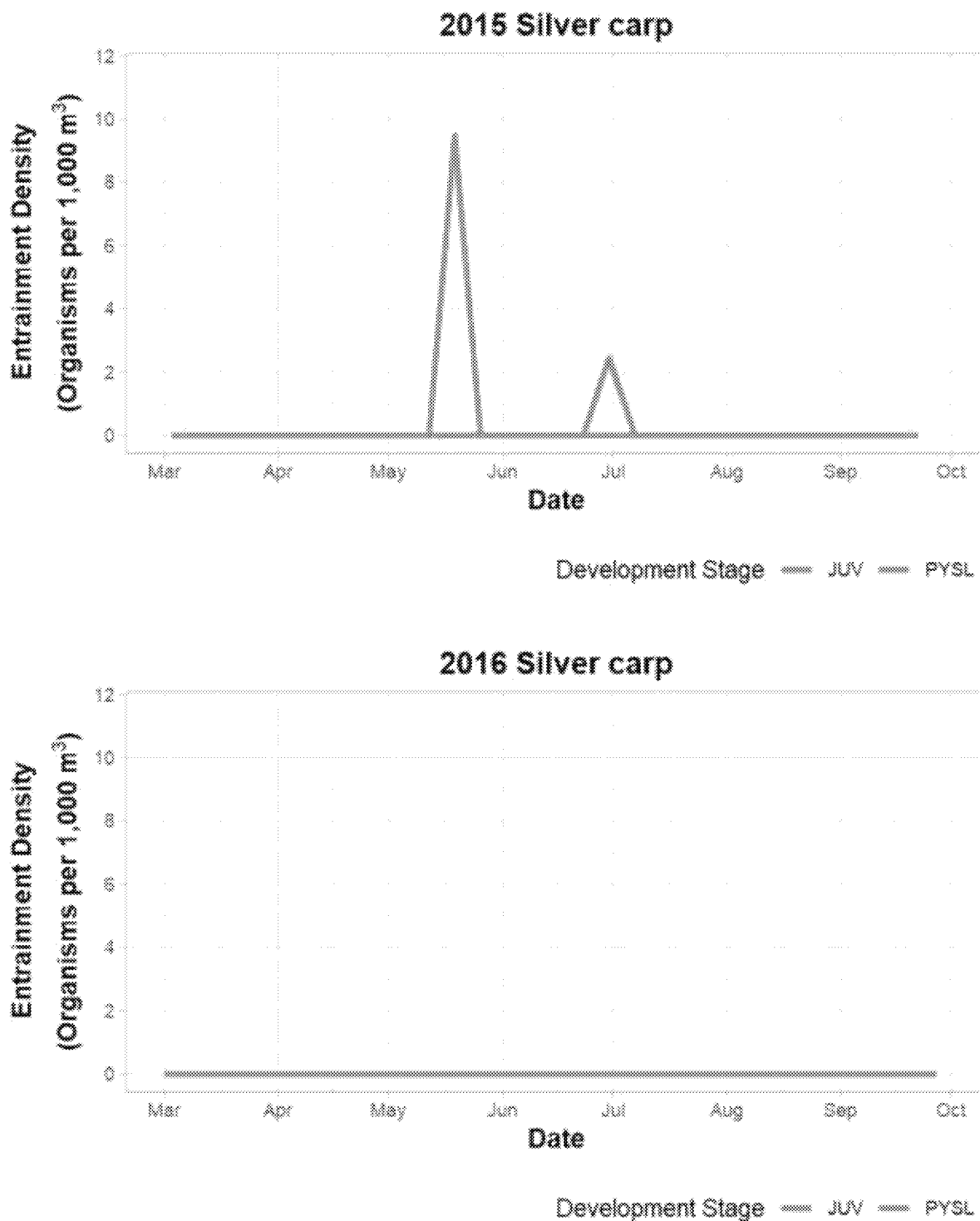
**Figure 9 B-29 Seasonal Pattern of Entrainment of Redhorses and Suckers (Subfamily Catostominae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



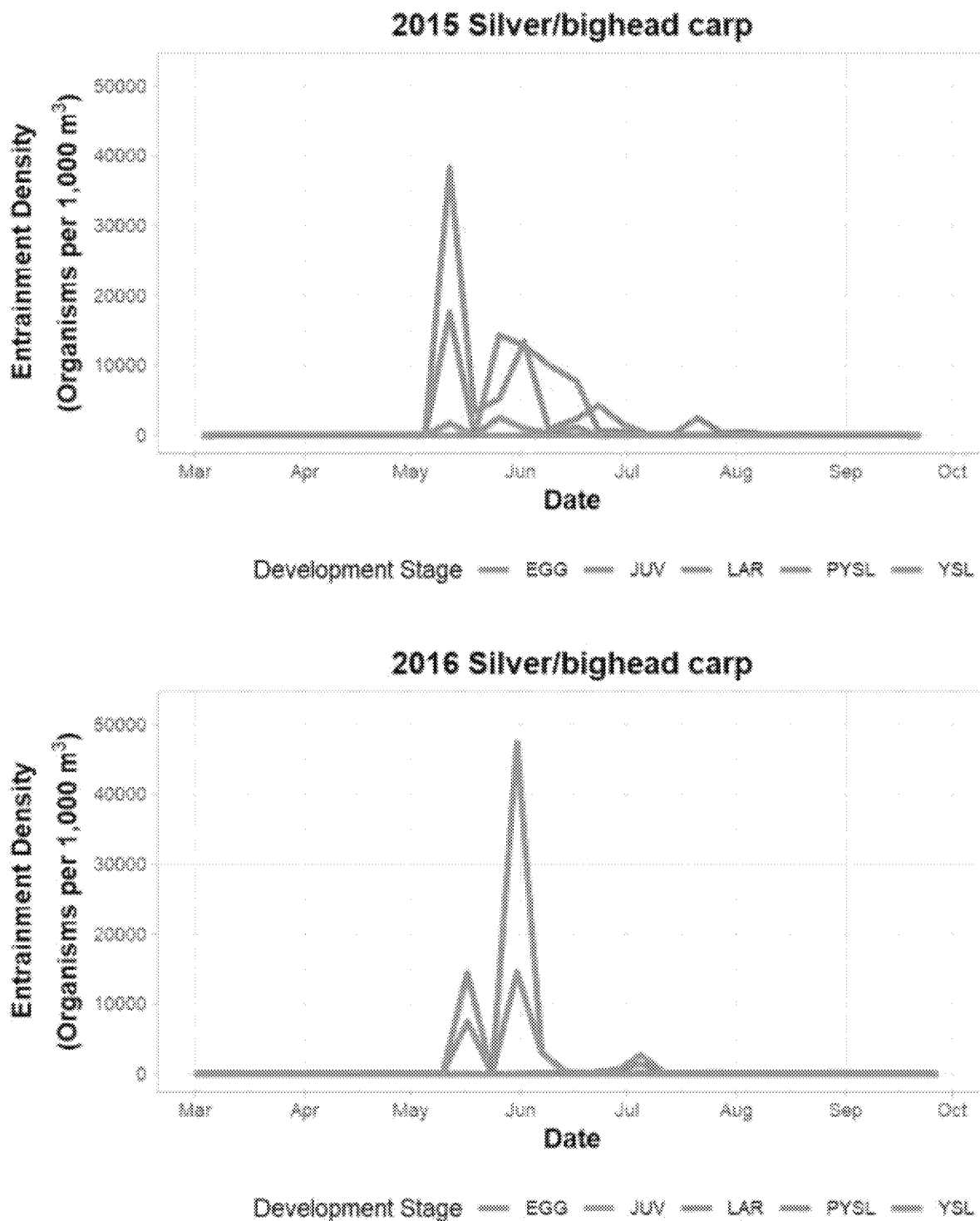
**Figure 9 B-30 Seasonal Pattern of Entrainment of Shoal Chub by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-31 Seasonal Pattern of Entrainment of Shortnose Gar by Development Stages  
Collected During 2015 and 2016 Sampling Conducted at the LEC.**

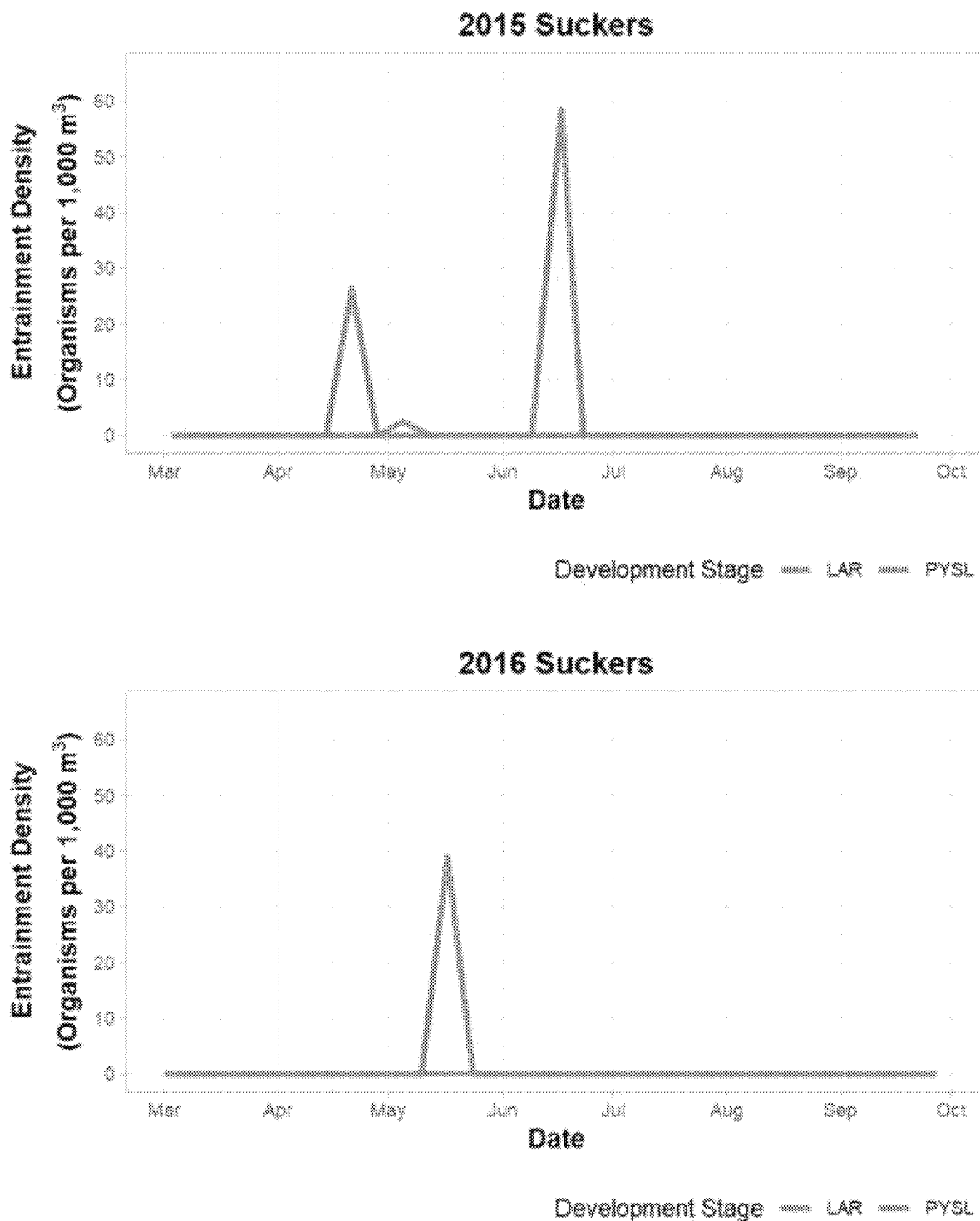


**Figure 9 B-32 Seasonal Pattern of Entrainment of Silver Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

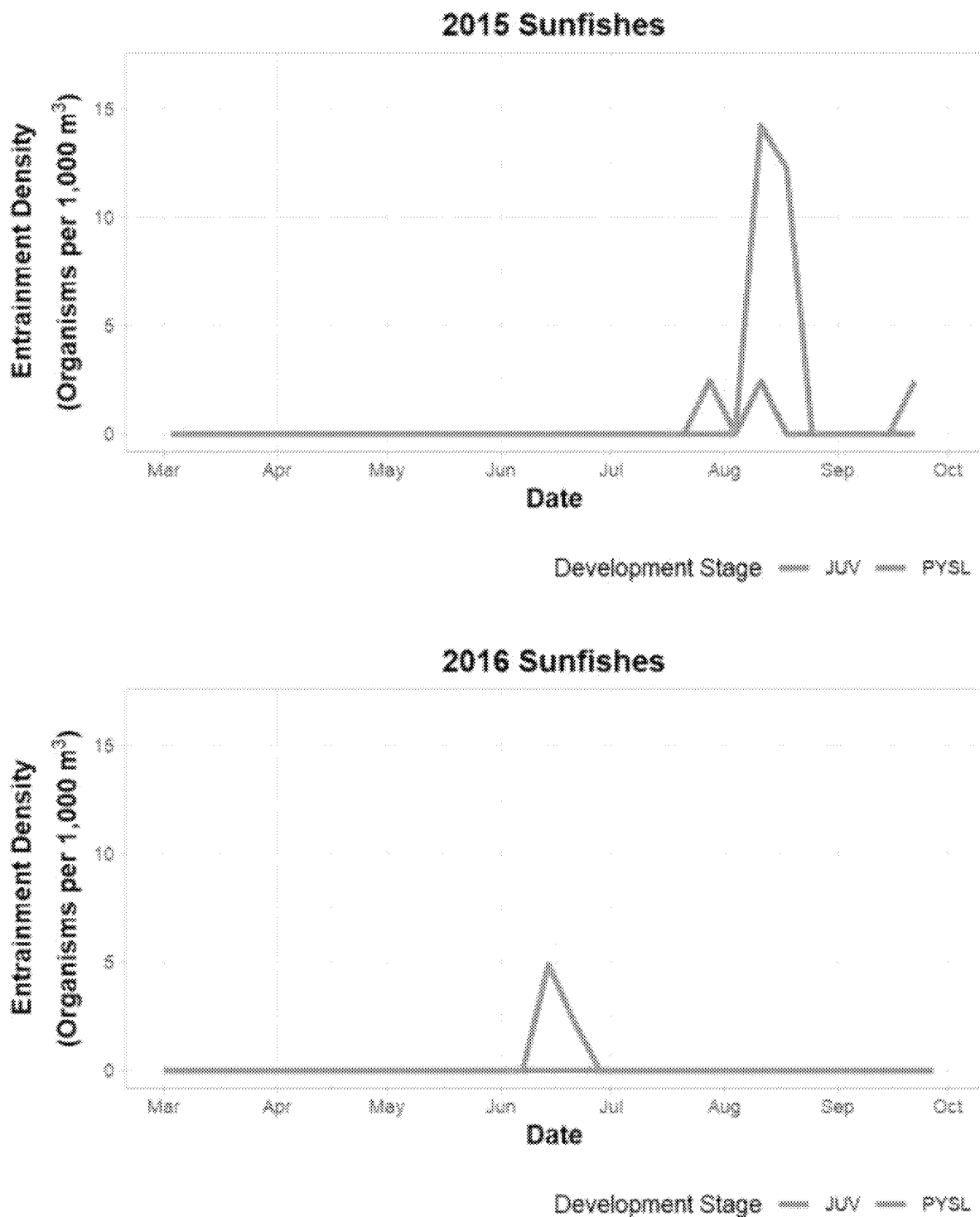


**Figure 9 B-33 Seasonal Pattern of Entrainment of Silver Carp and Bighead Carp**  
(*Hypophthalmichthys* sp.) by Development Stages Collected During 2015 and 2016  
Sampling Conducted at the LEC.





**Figure 9 B-34 Seasonal Pattern of Entrainment of Sucker Family (Catostomidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-35 Seasonal Pattern of Entrainment of Sunfish Family (Centrarchidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

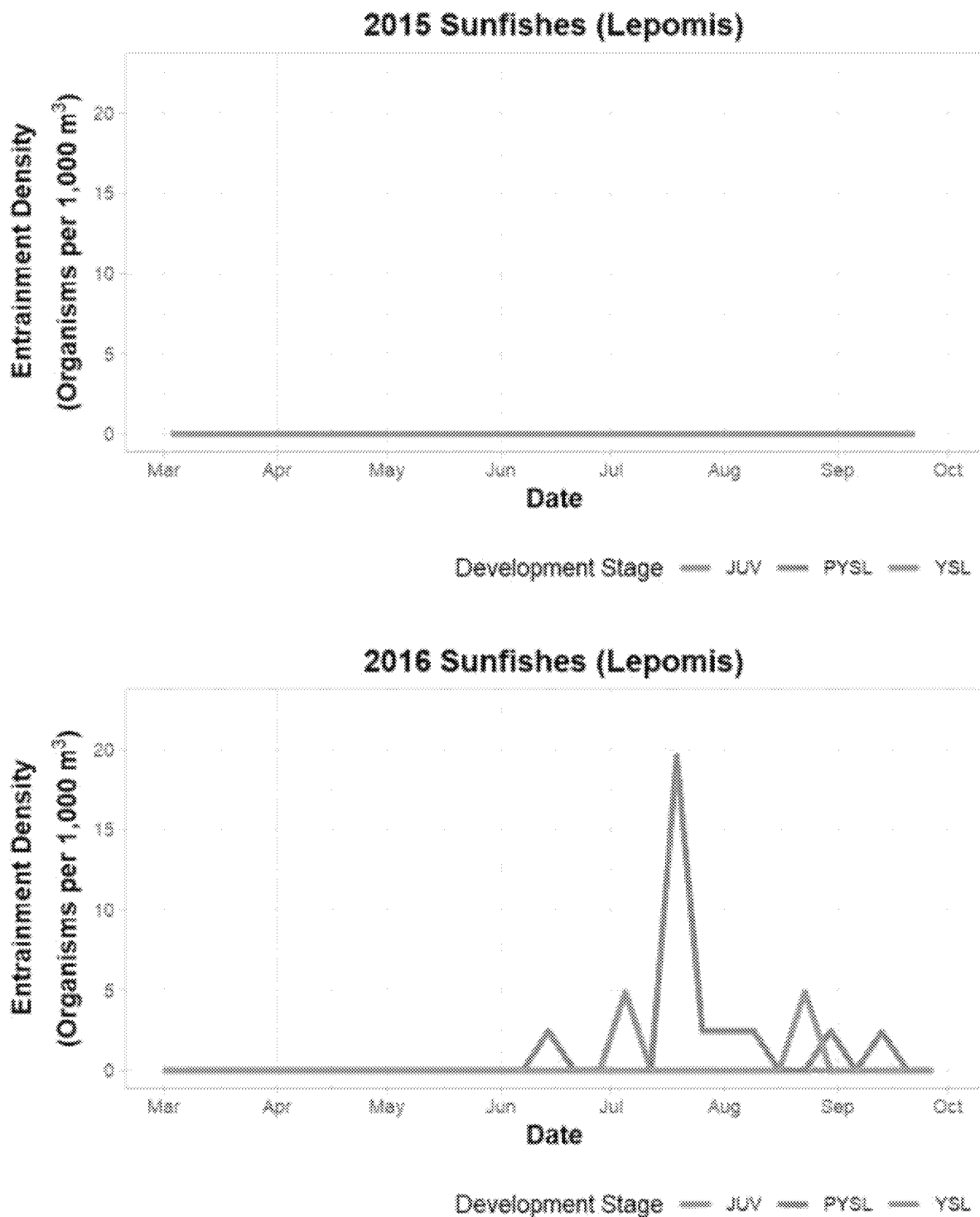
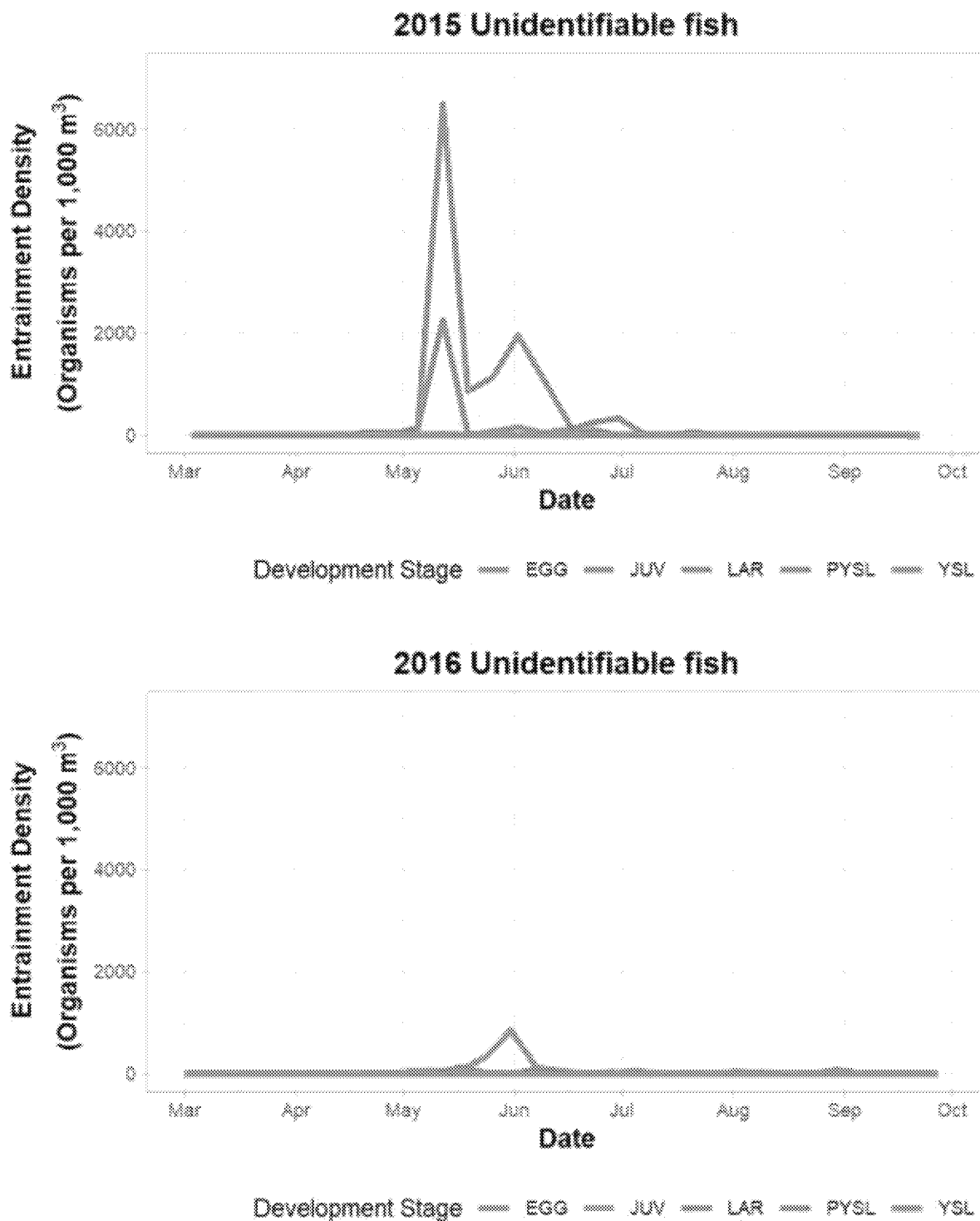
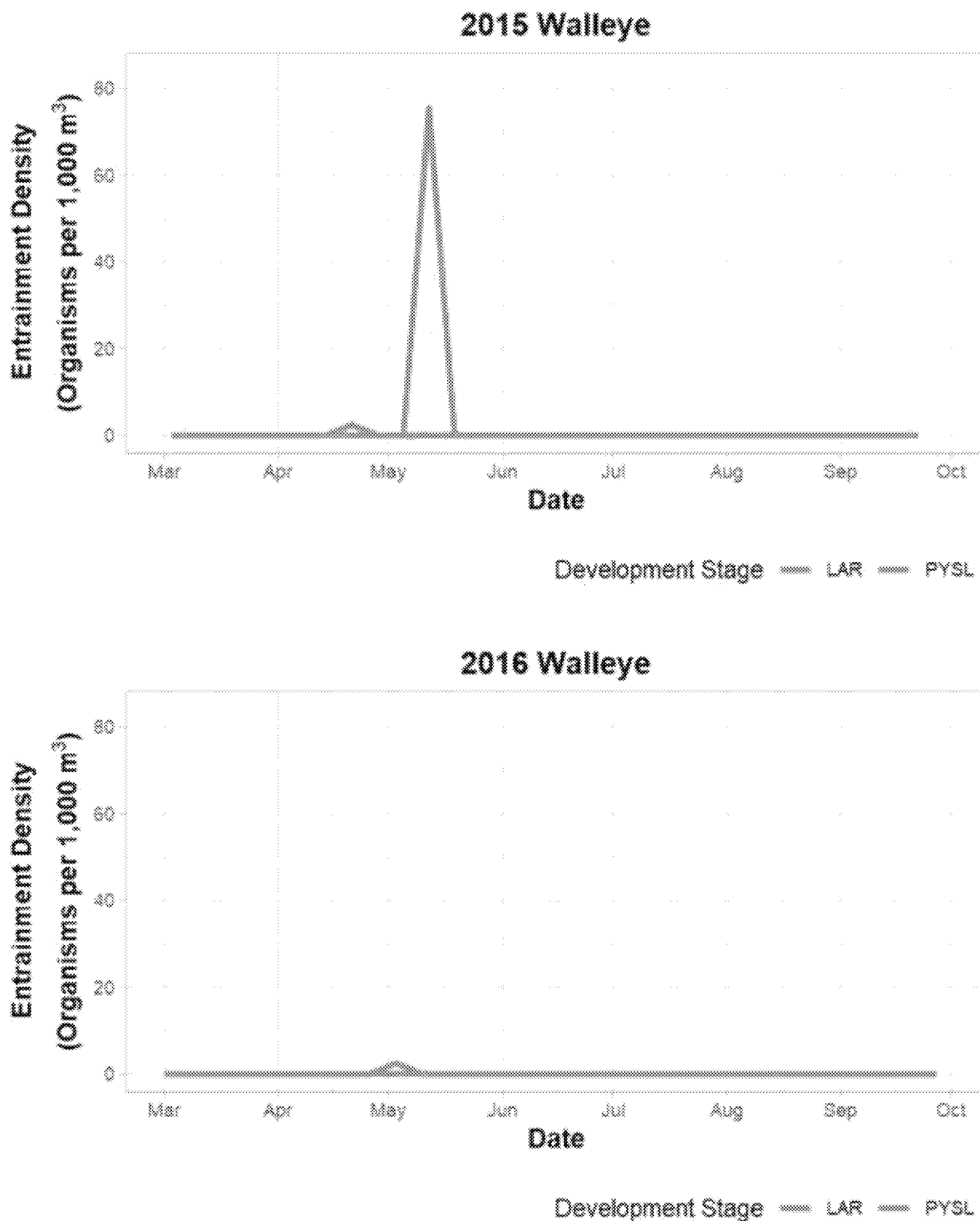


Figure 9 B-36 Seasonal Pattern of Entrainment of Sunfishes (*Lepomis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-37 Seasonal Pattern of Entrainment of Unidentifiable Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-38 Seasonal Pattern of Entrainment of Walleye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

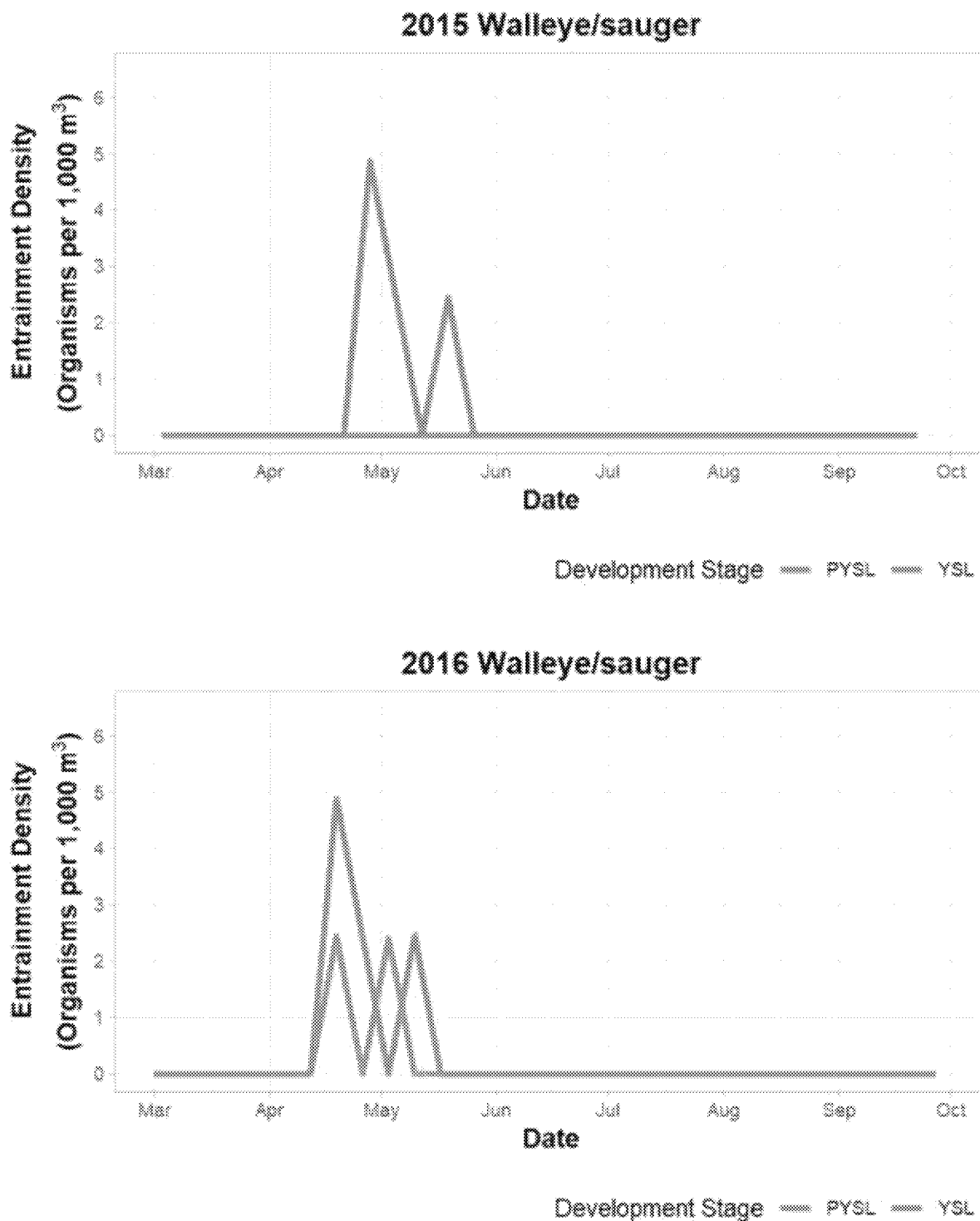
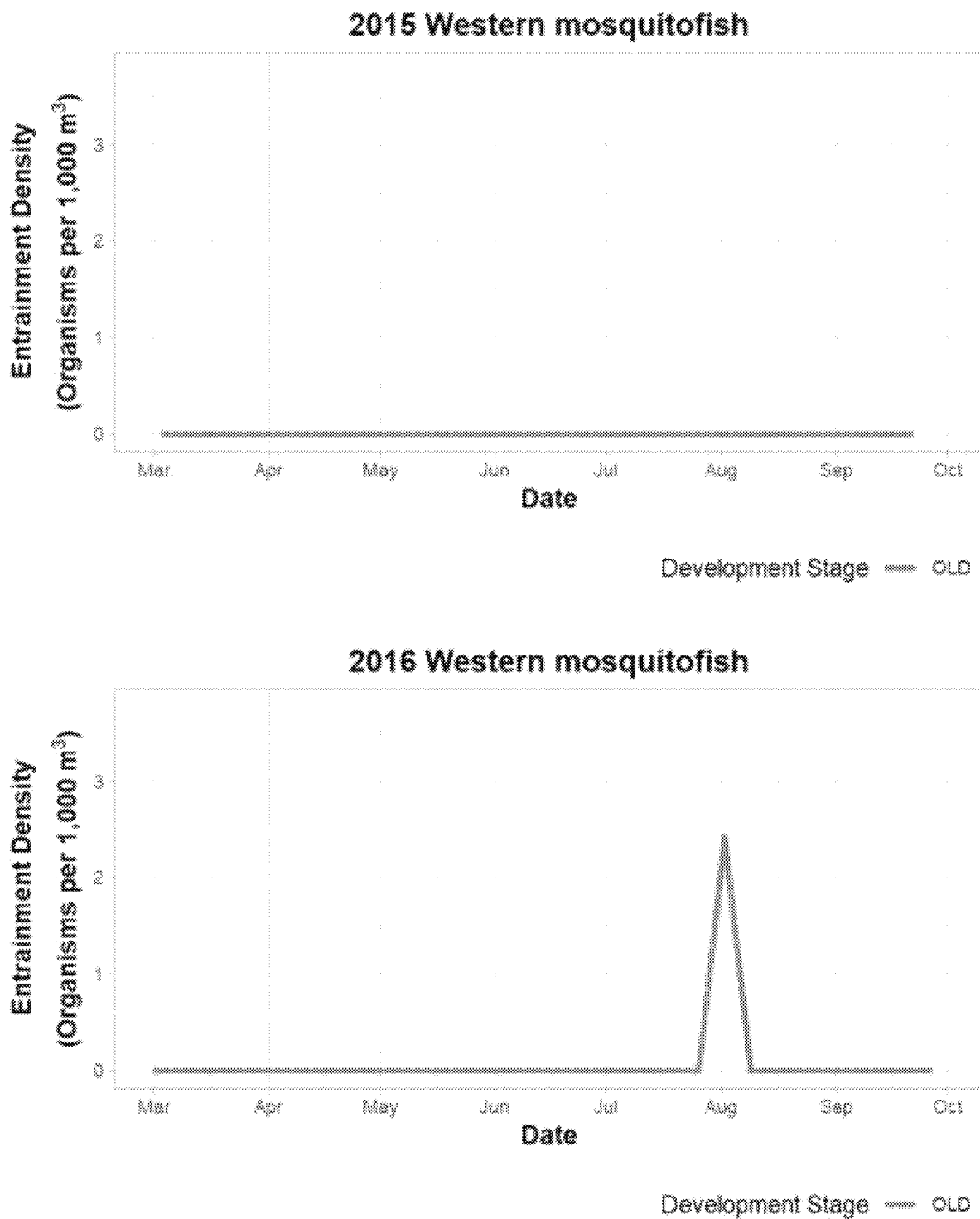
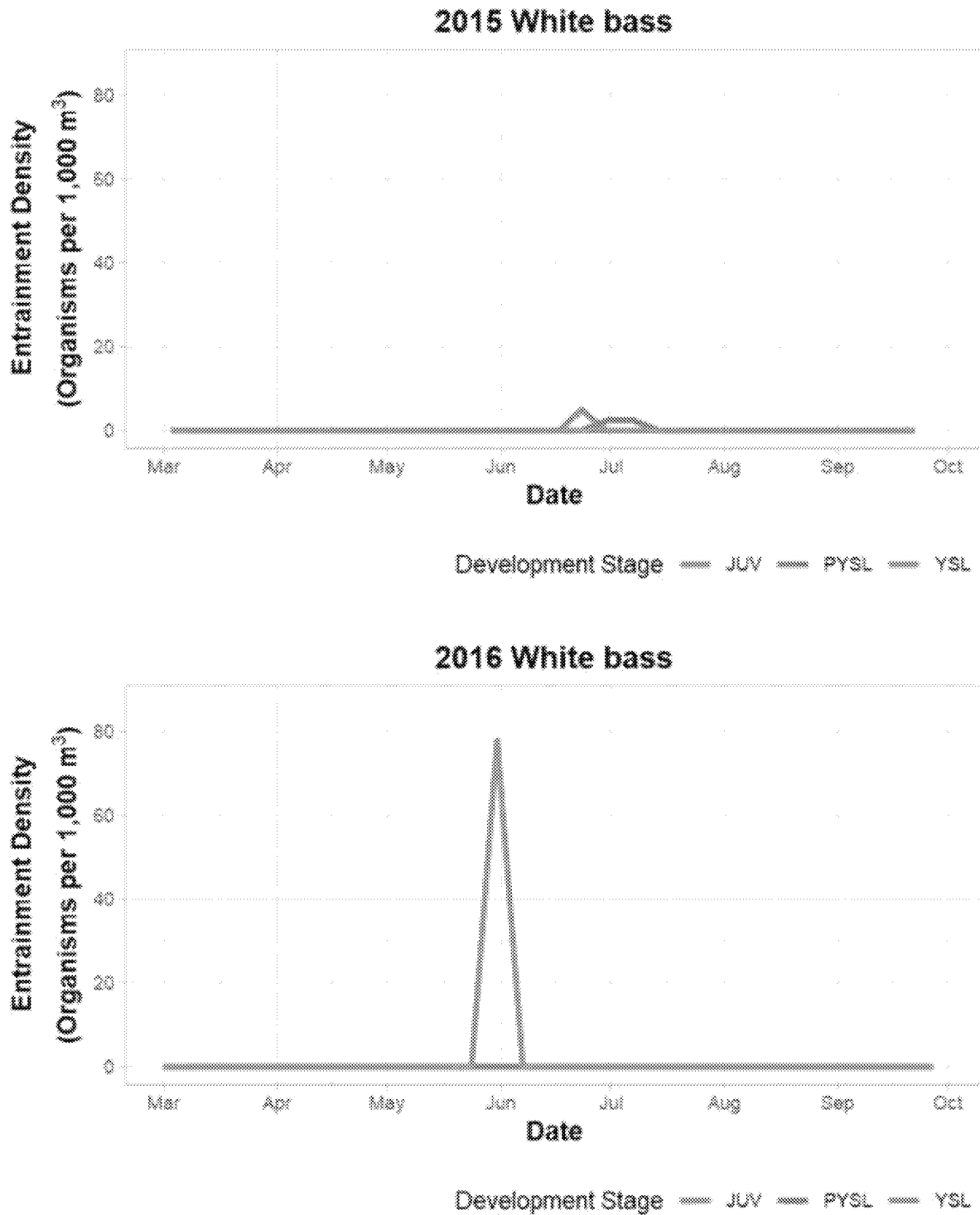


Figure 9 B-39 Seasonal Pattern of Entrainment of Walleye and Sauger (*Sander* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 B-40 Seasonal Pattern of Entrainment of Western Mosquitofish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 B-41 Seasonal Pattern of Entrainment of White Bass by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



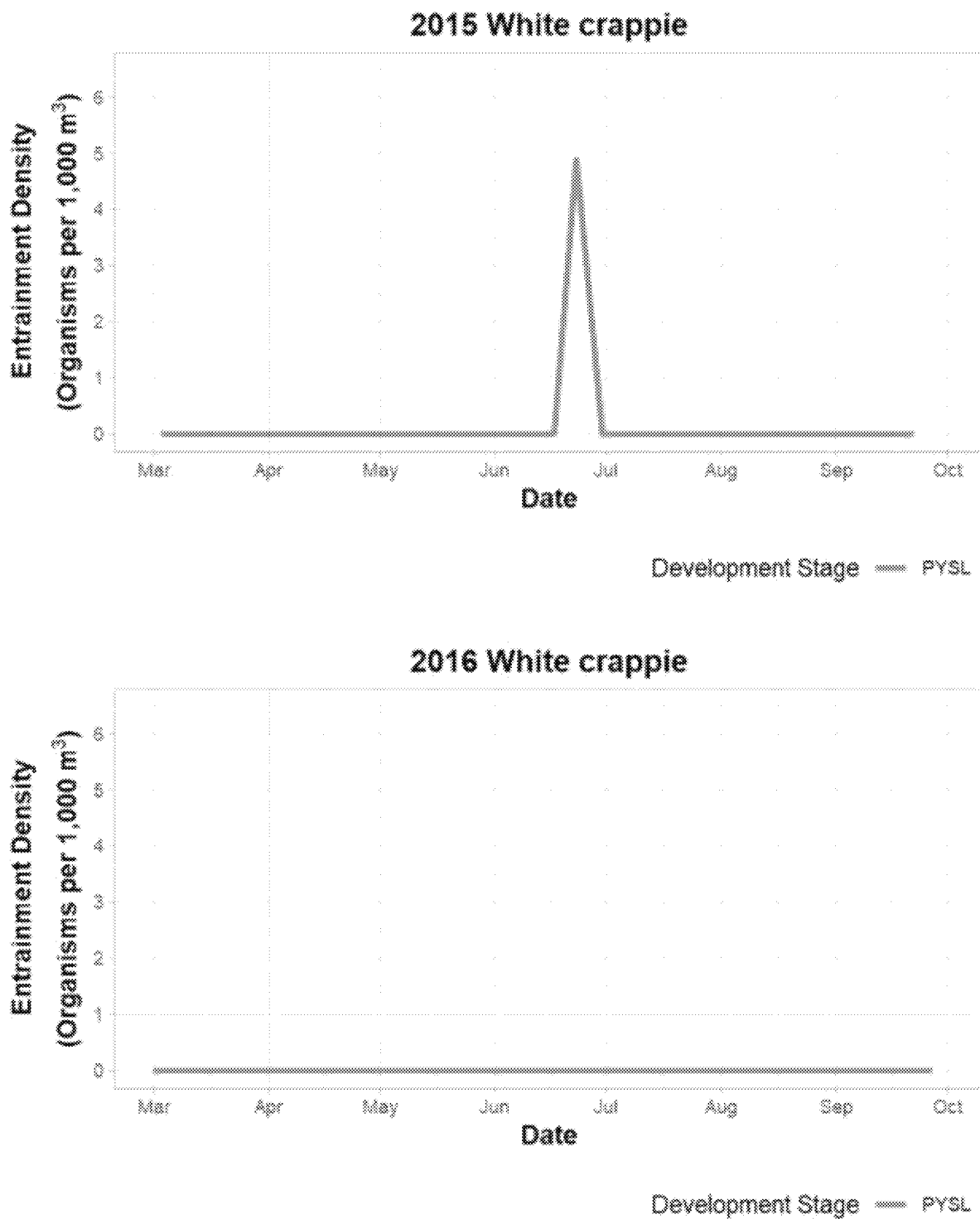


Figure 9 B-42 Seasonal Pattern of Entrainment of White Crappie by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

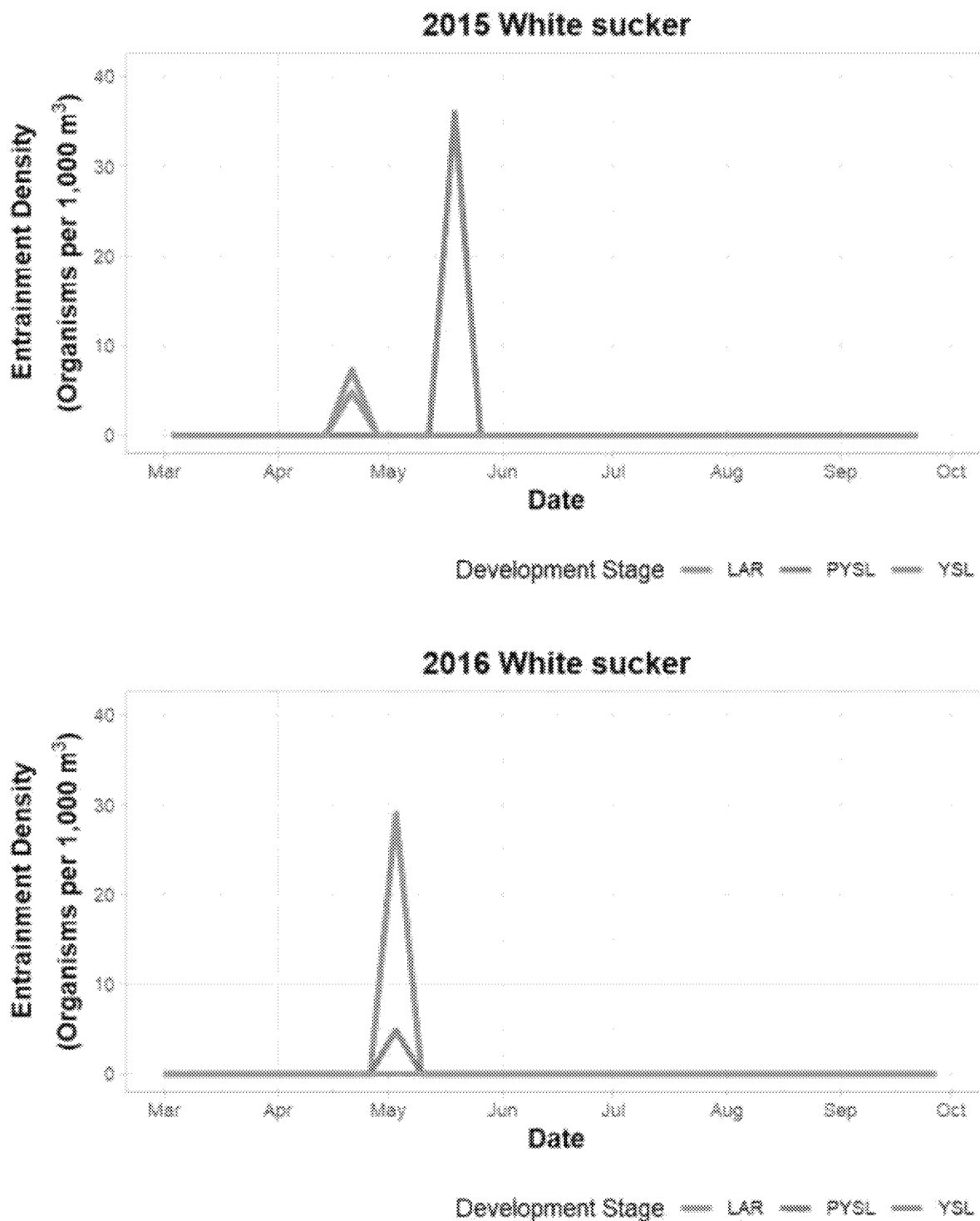
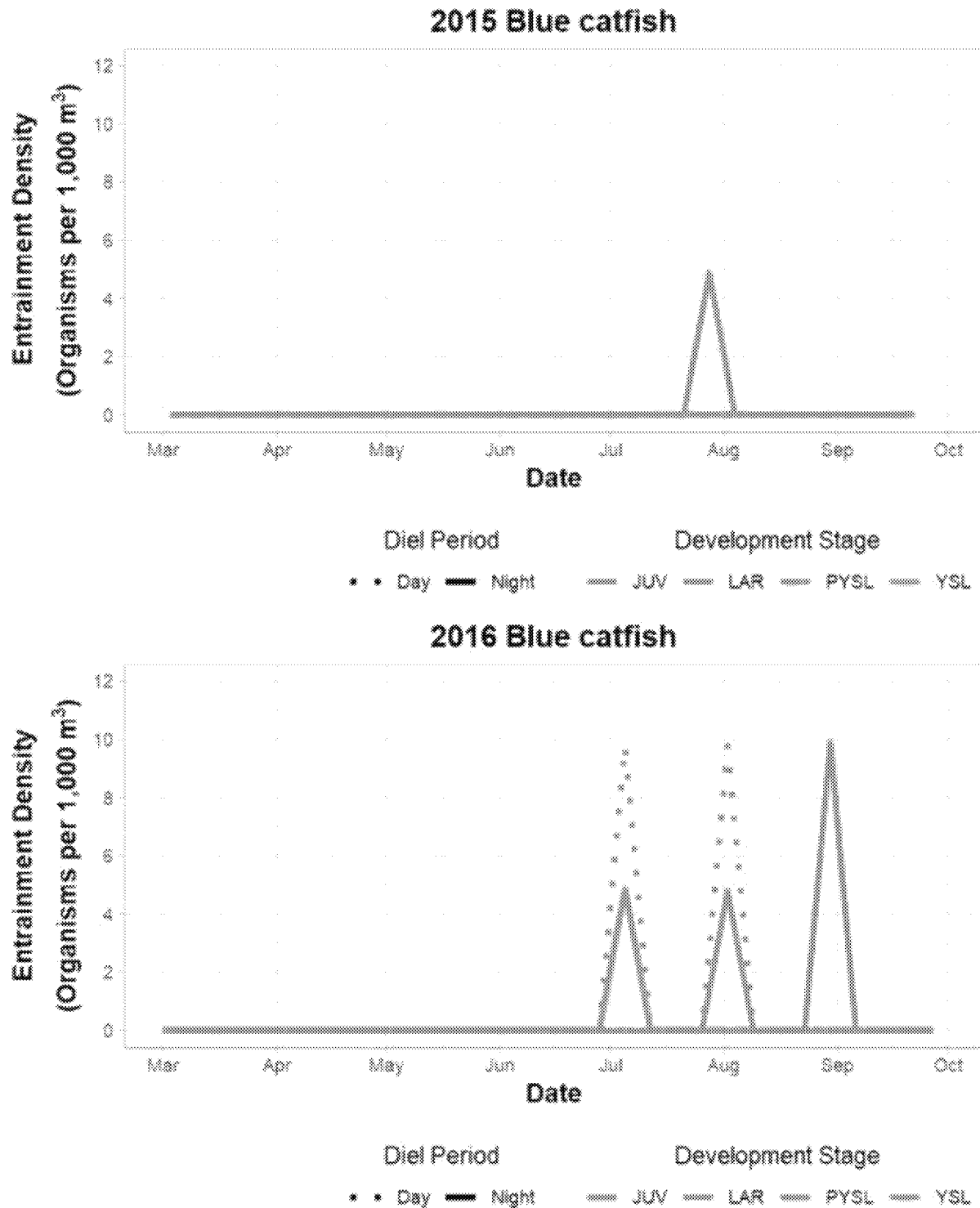


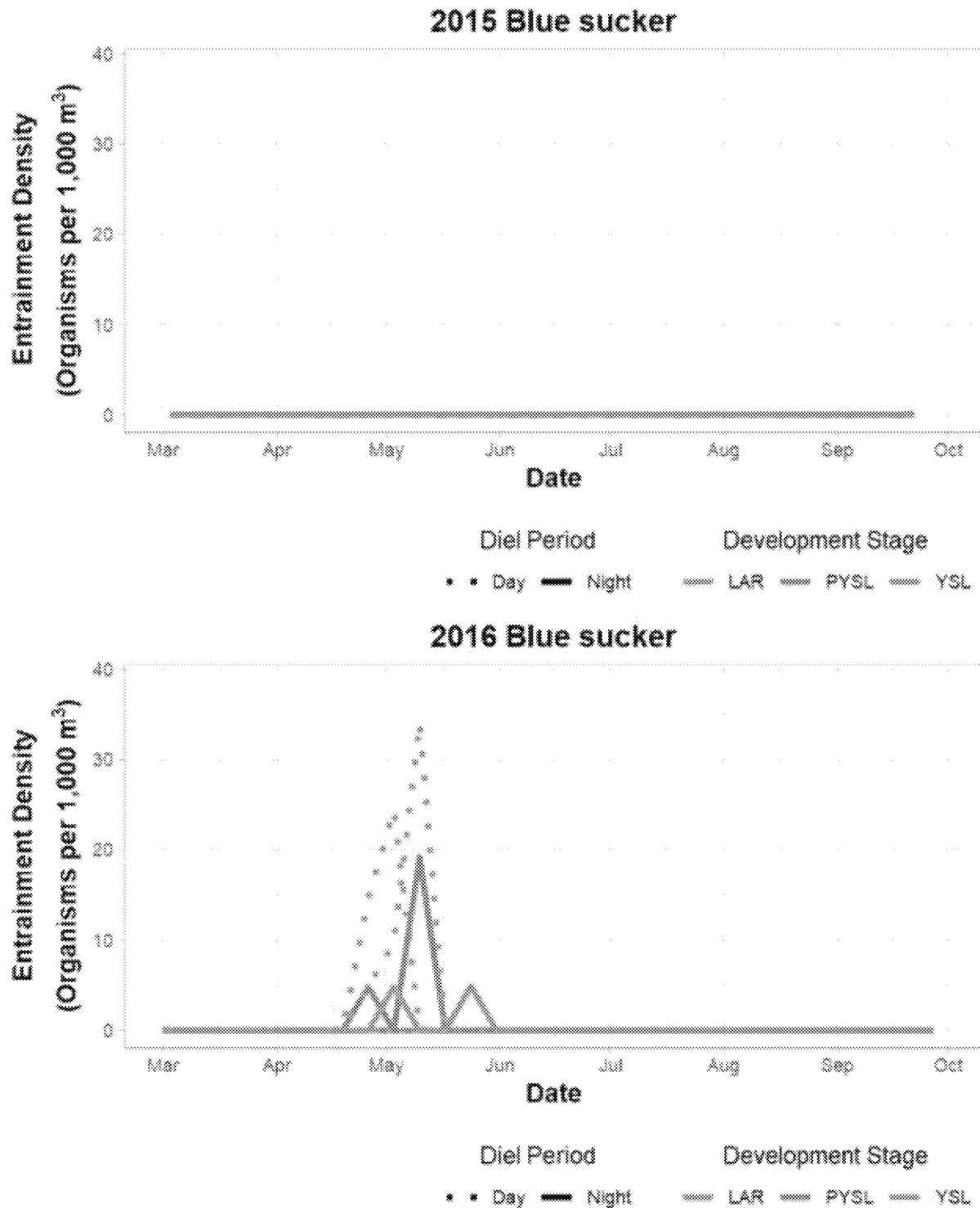
Figure 9 B-43 Seasonal Pattern of Entrainment of White Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

**Appendix 9 C**  
**40 CFR 122.21(r)(9) – Entrainment Characterization Study**

**Diel Patterns of Entrainment of All Taxa and Development Stages at  
Labadie Energy Center, 2015 and 2016**



**Figure 9 C-1 Mean Daytime and Nighttime Entrainment of Blue Catfish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 C-2 Mean Daytime and Nighttime Entrainment of Blue Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

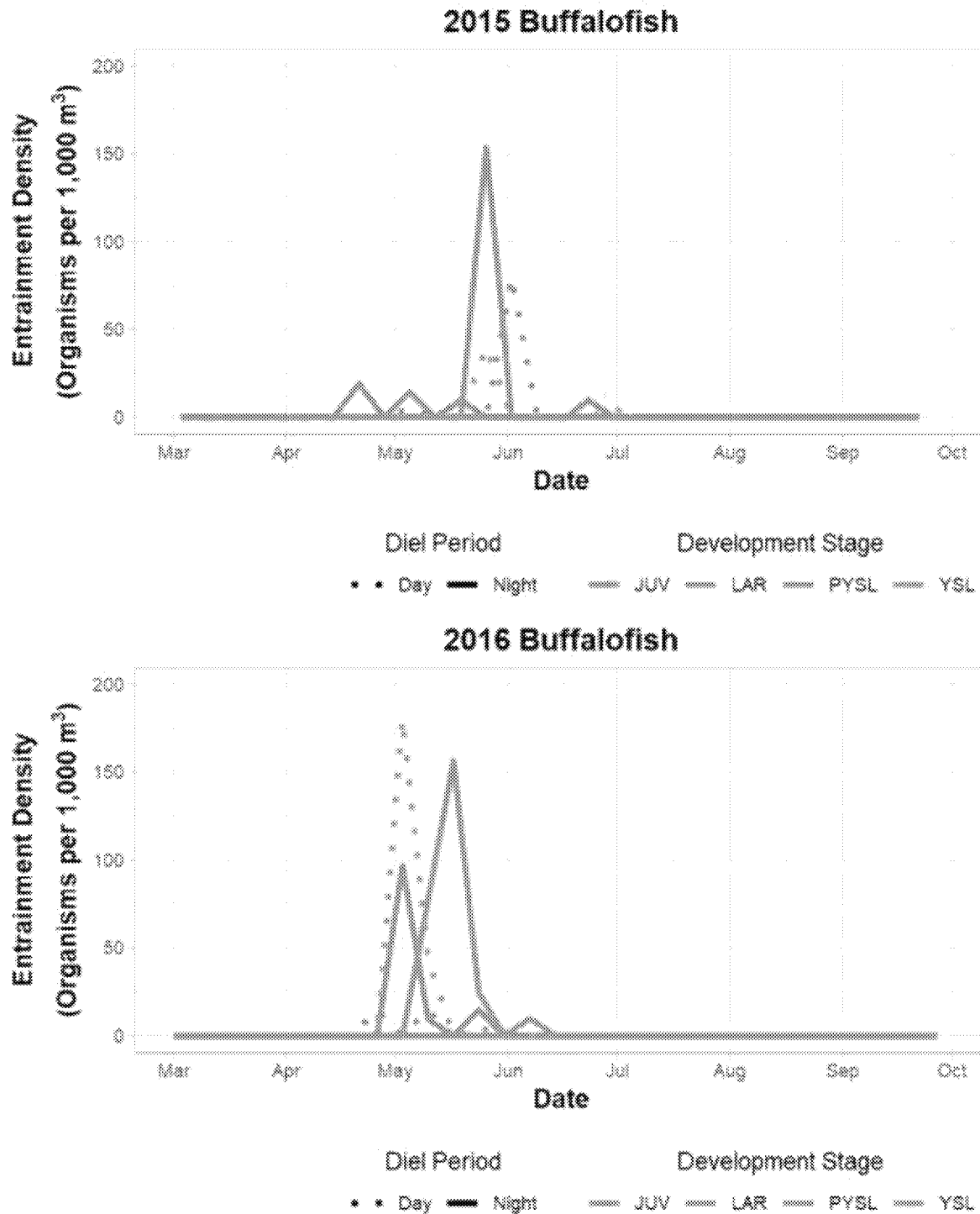


Figure 9 C-3 Mean Daytime and Nighttime Entrainment of Buffalos (*Ictiobus* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

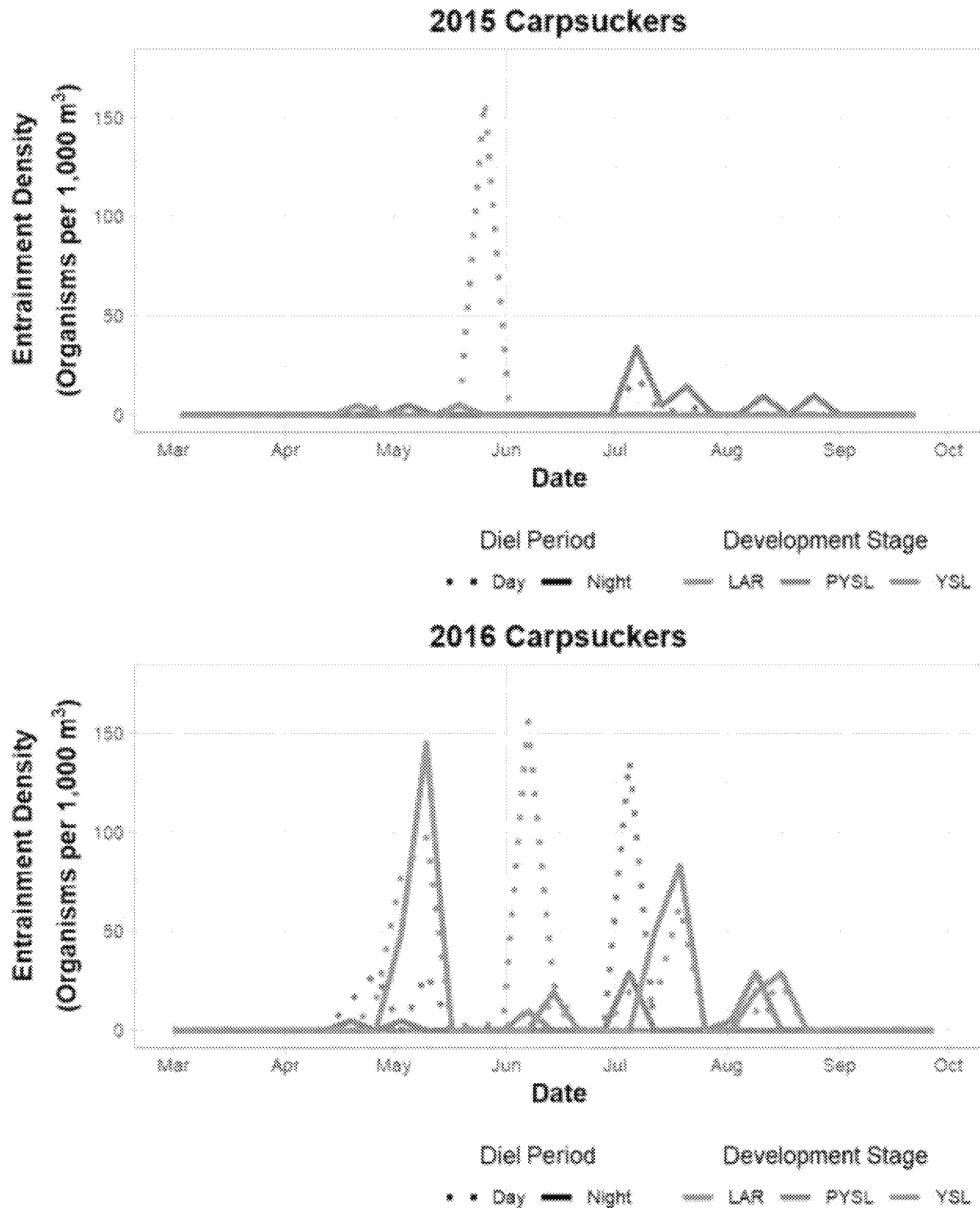
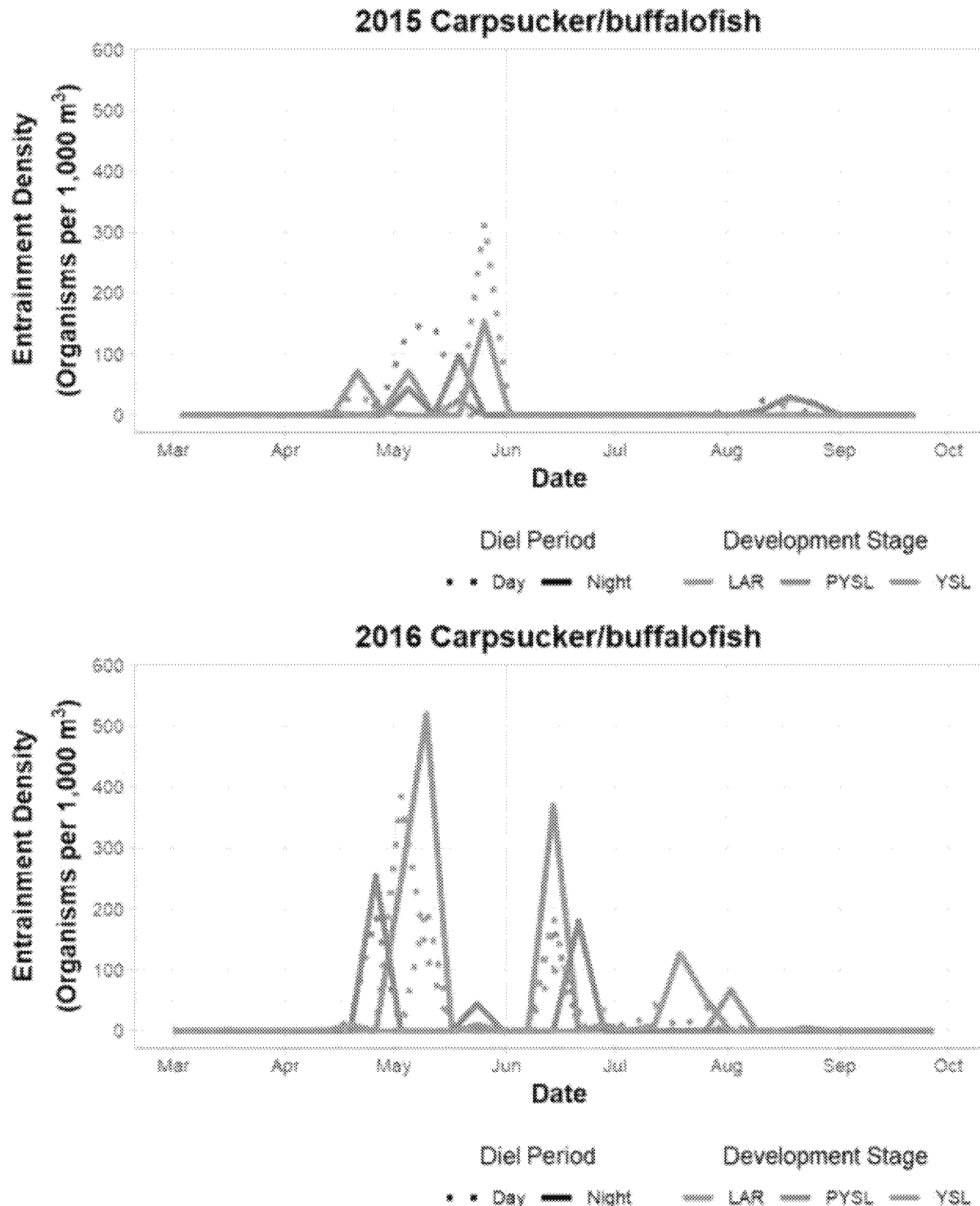


Figure 9 C-4 Mean Daytime and Nighttime Entrainment of Carpsuckers (*Carpiodes* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-5 Mean Daytime and Nighttime Entrainment of Carpsuckers and Buffalos (Subfamily Ictiobinae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



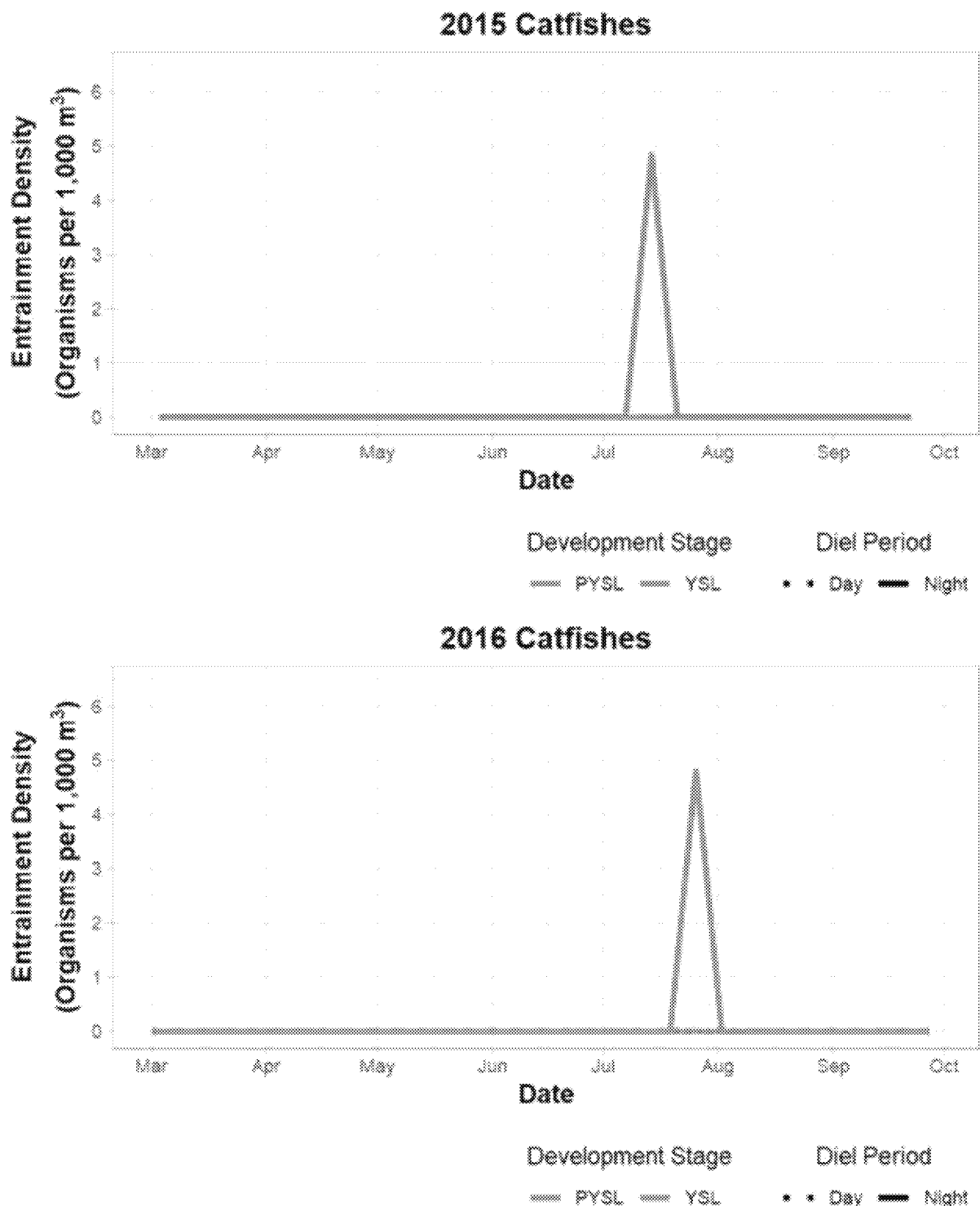


Figure 9 C-6 Mean Daytime and Nighttime Entrainment of North American Catfishes (Family Ictaluridae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

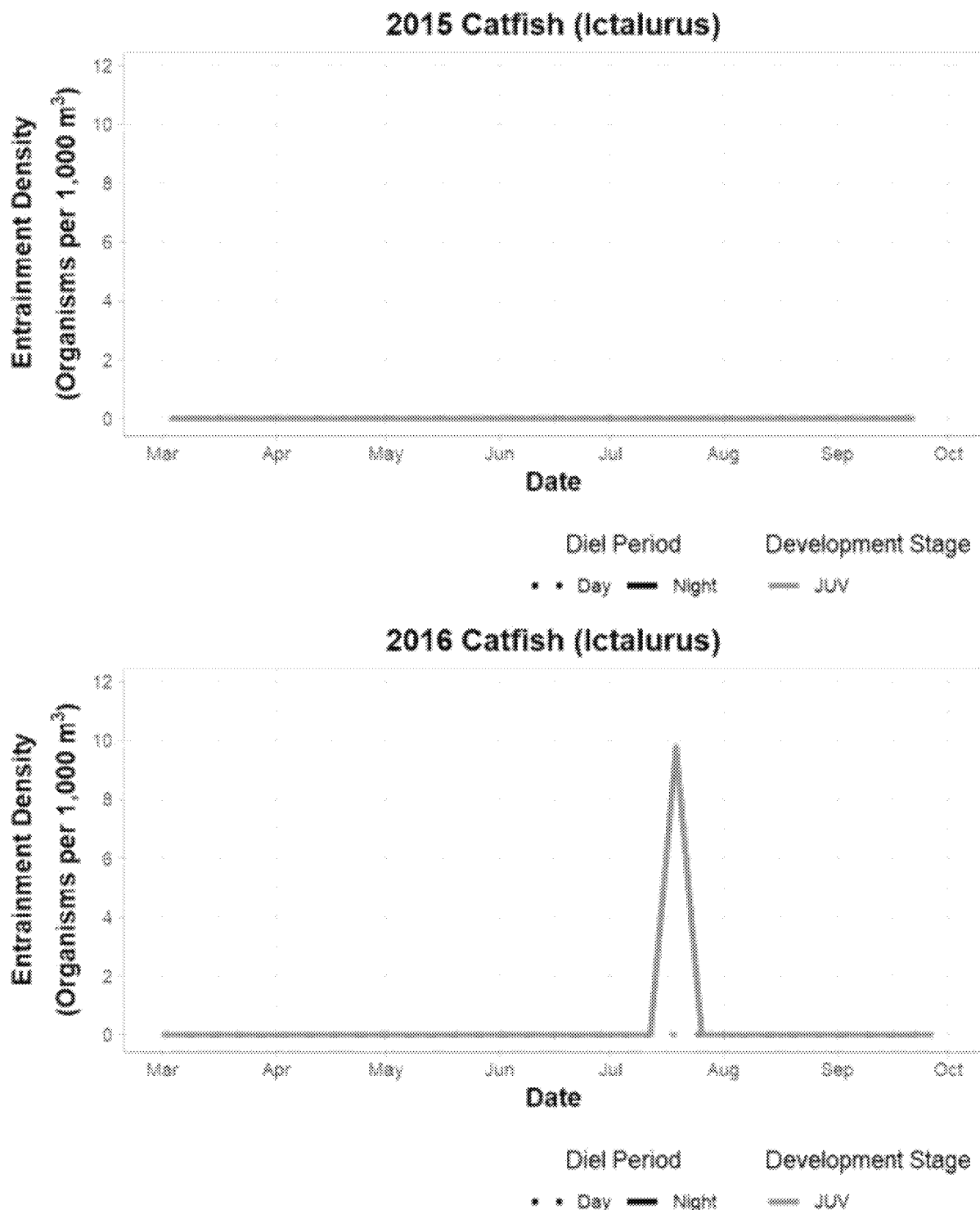


Figure 9 C-7 Mean Daytime and Nighttime Entrainment of Catfishes (*Ictalurus* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

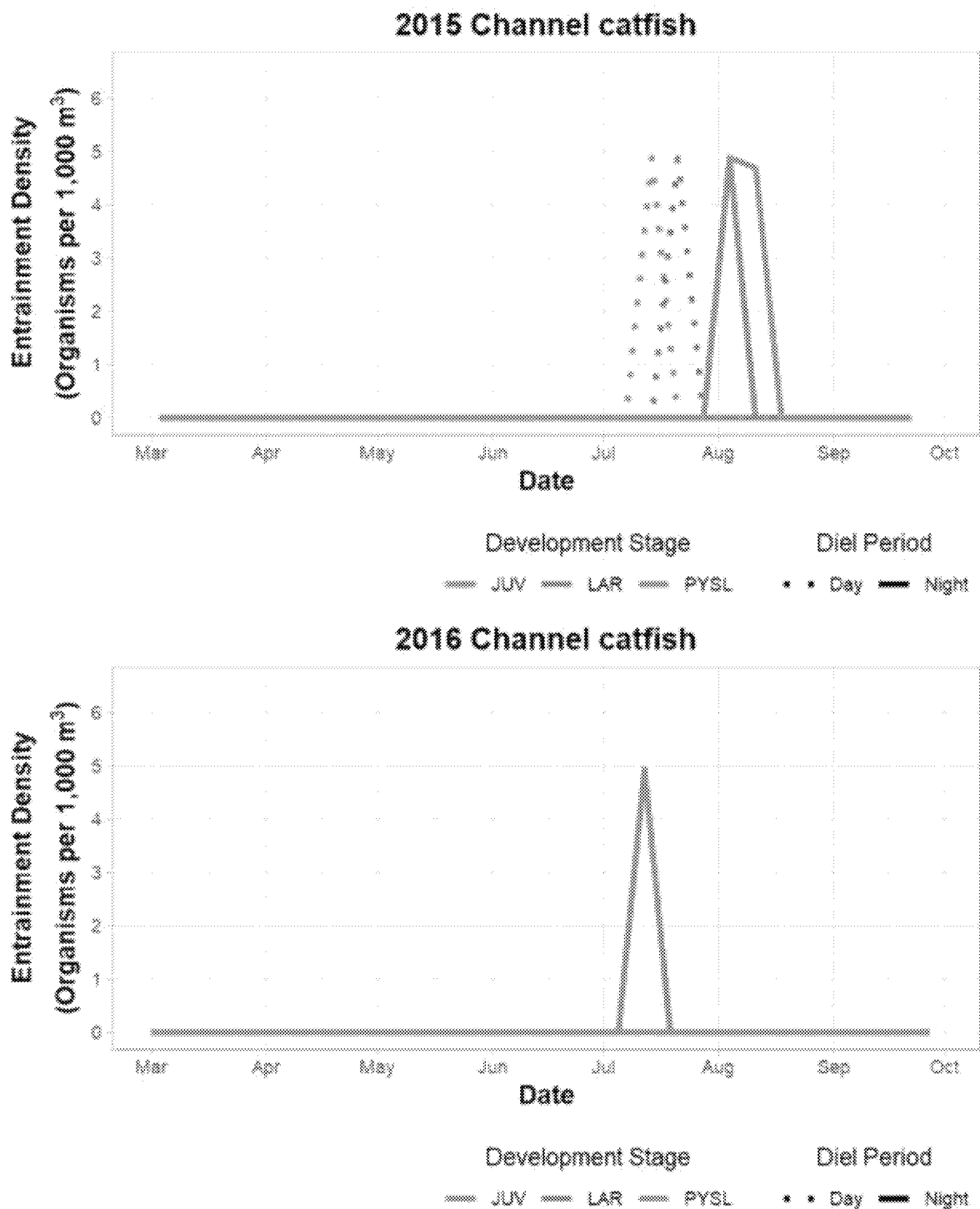
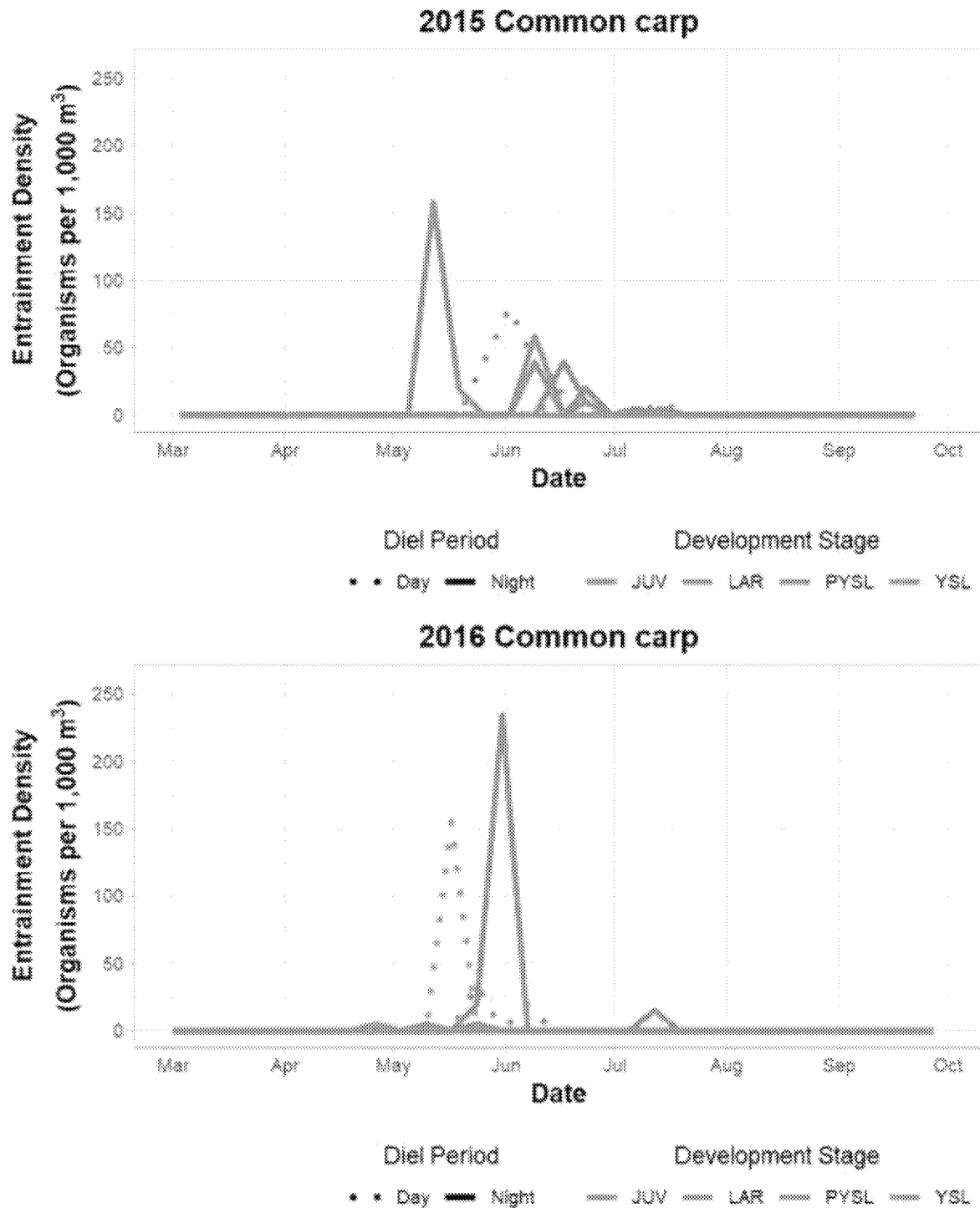


Figure 9 C-8 Mean Daytime and Nighttime Entrainment of Channel Catfish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-9 Mean Daytime and Nighttime Entrainment of Common Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

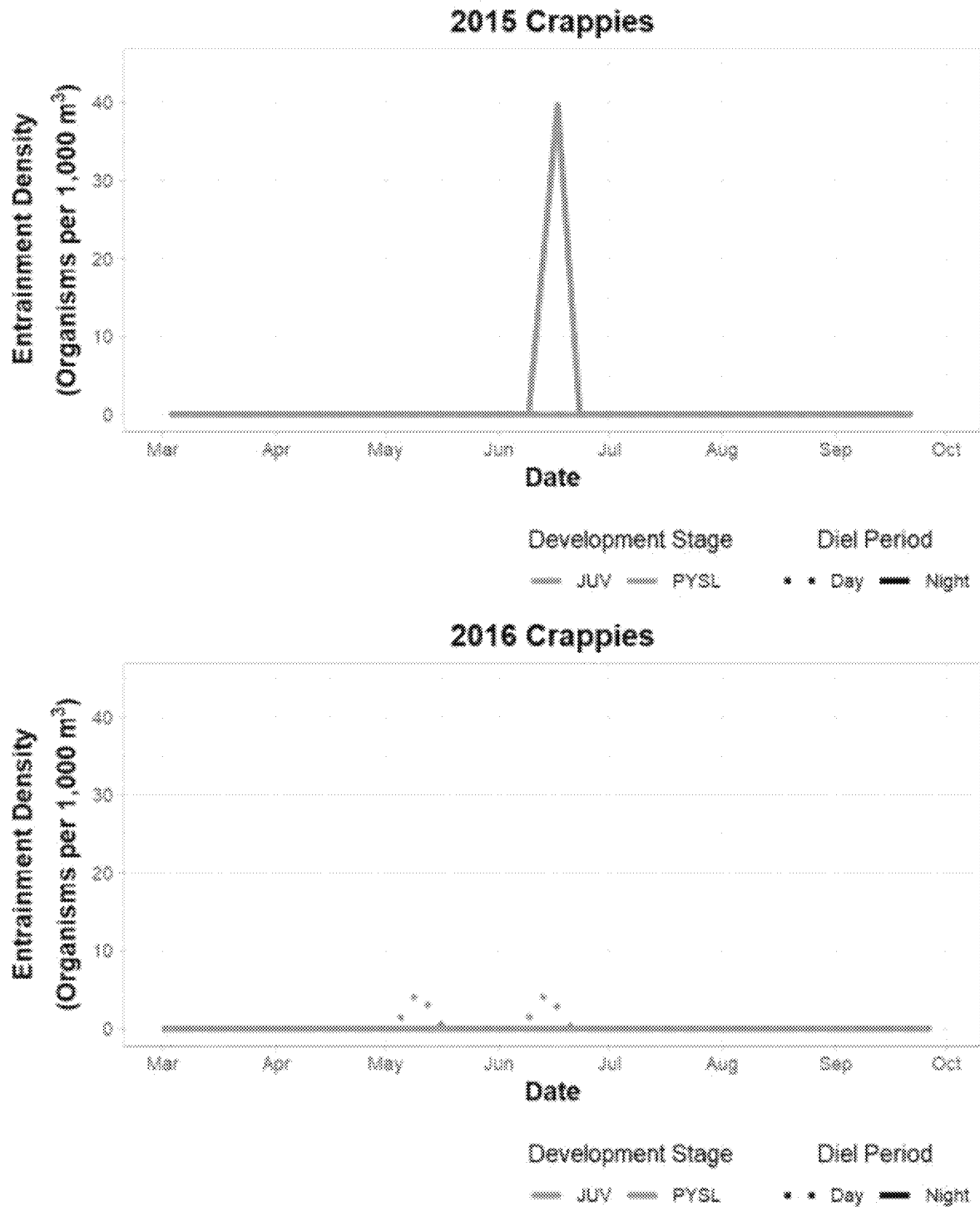


Figure 9 C-10 Mean Daytime and Nighttime Entrainment of Crappies (*Pomoxis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

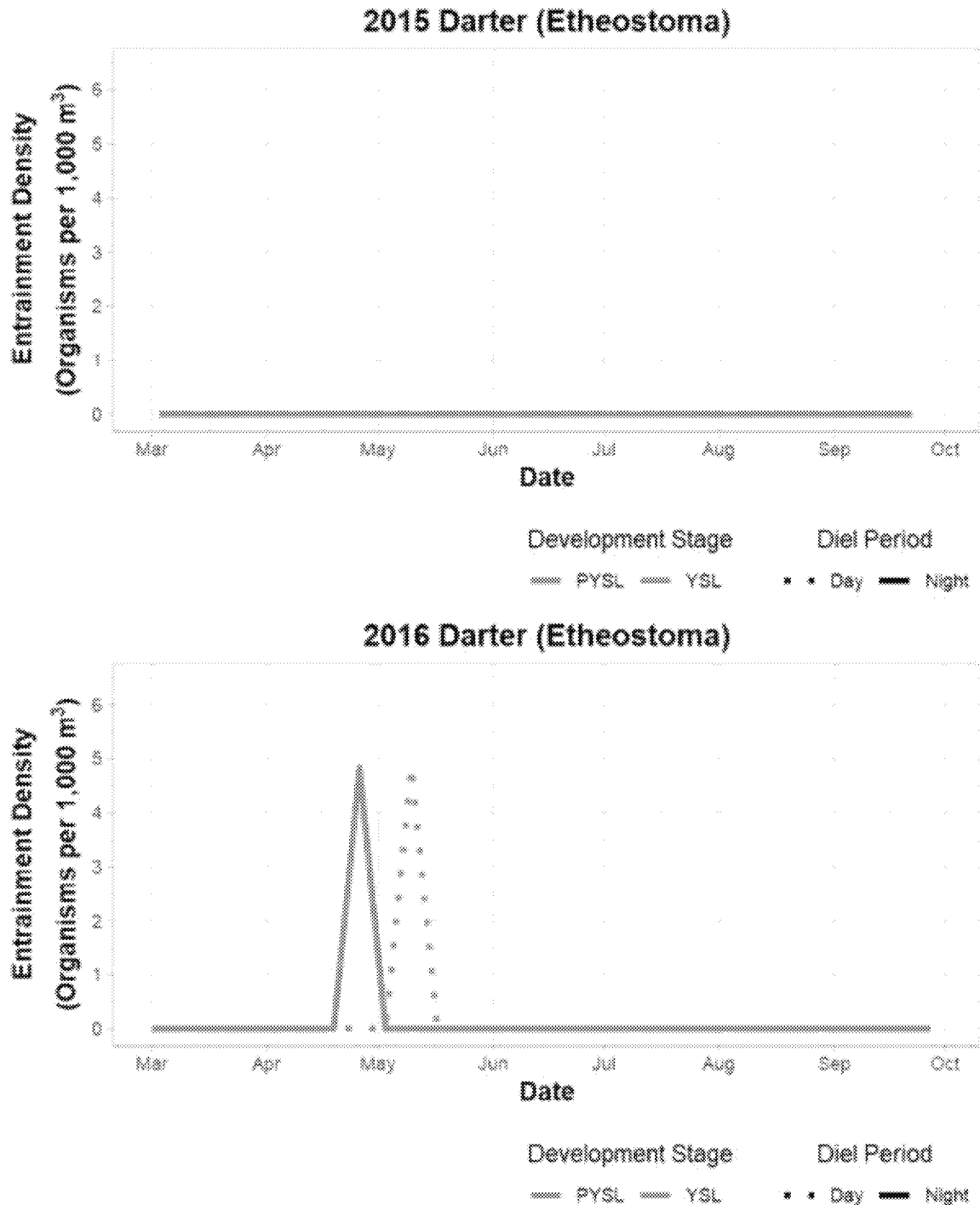


Figure 9 C-11 Mean Daytime and Nighttime Entrainment of Darters (*Etheostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

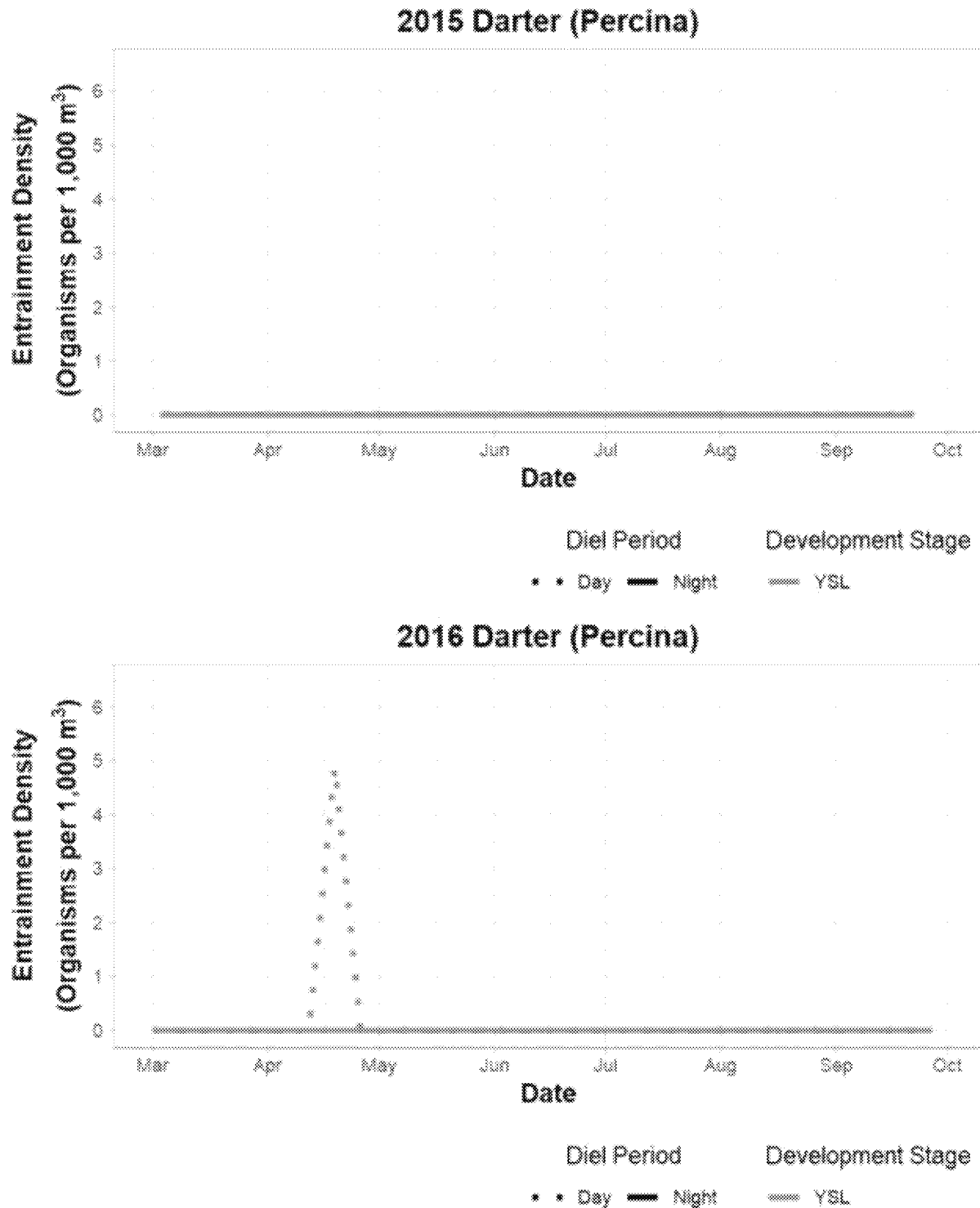
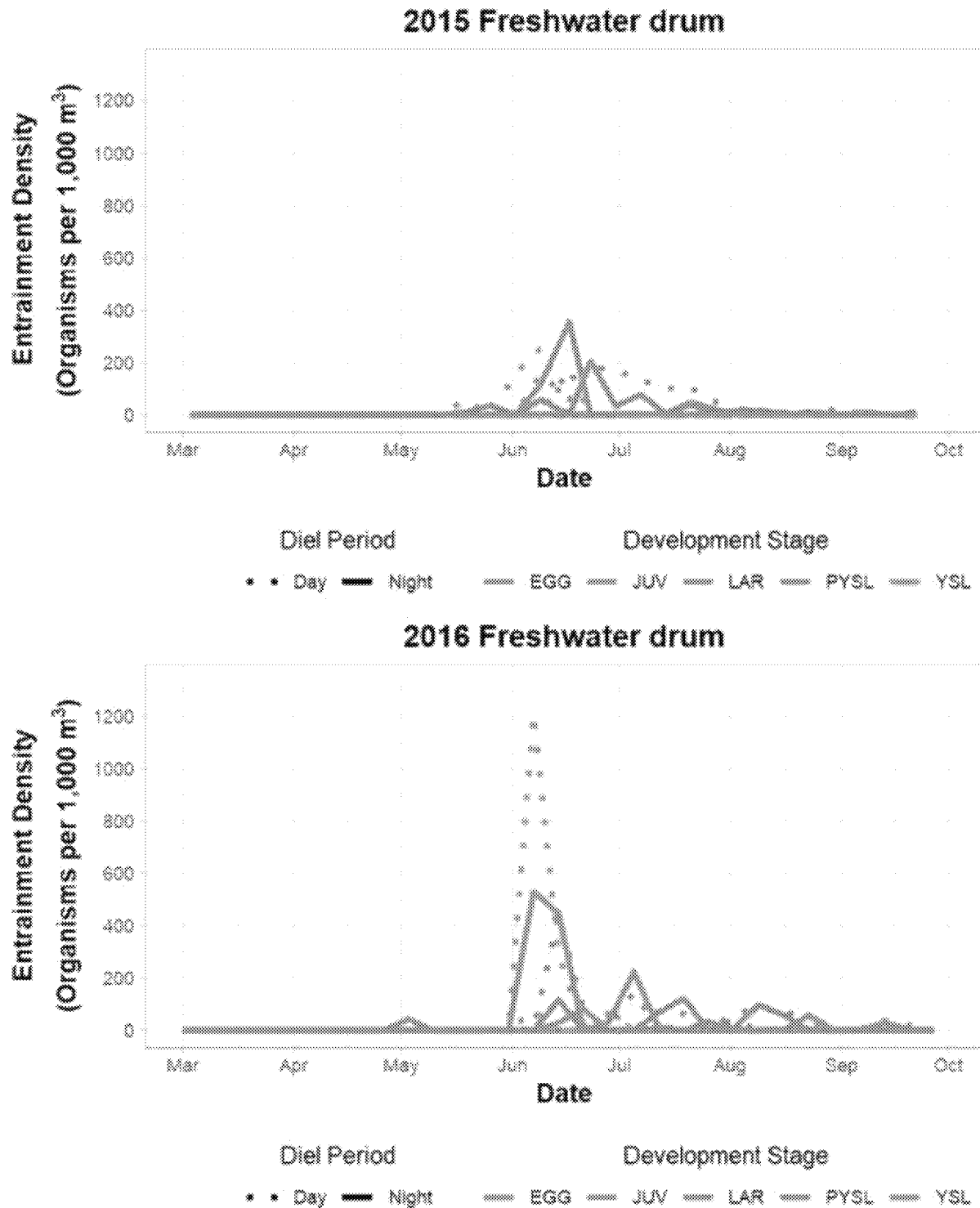


Figure 9 C-12 Mean Daytime and Nighttime Entrainment of Darters (*Percina* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-13 Mean Daytime and Nighttime Entrainment of Freshwater Drum by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



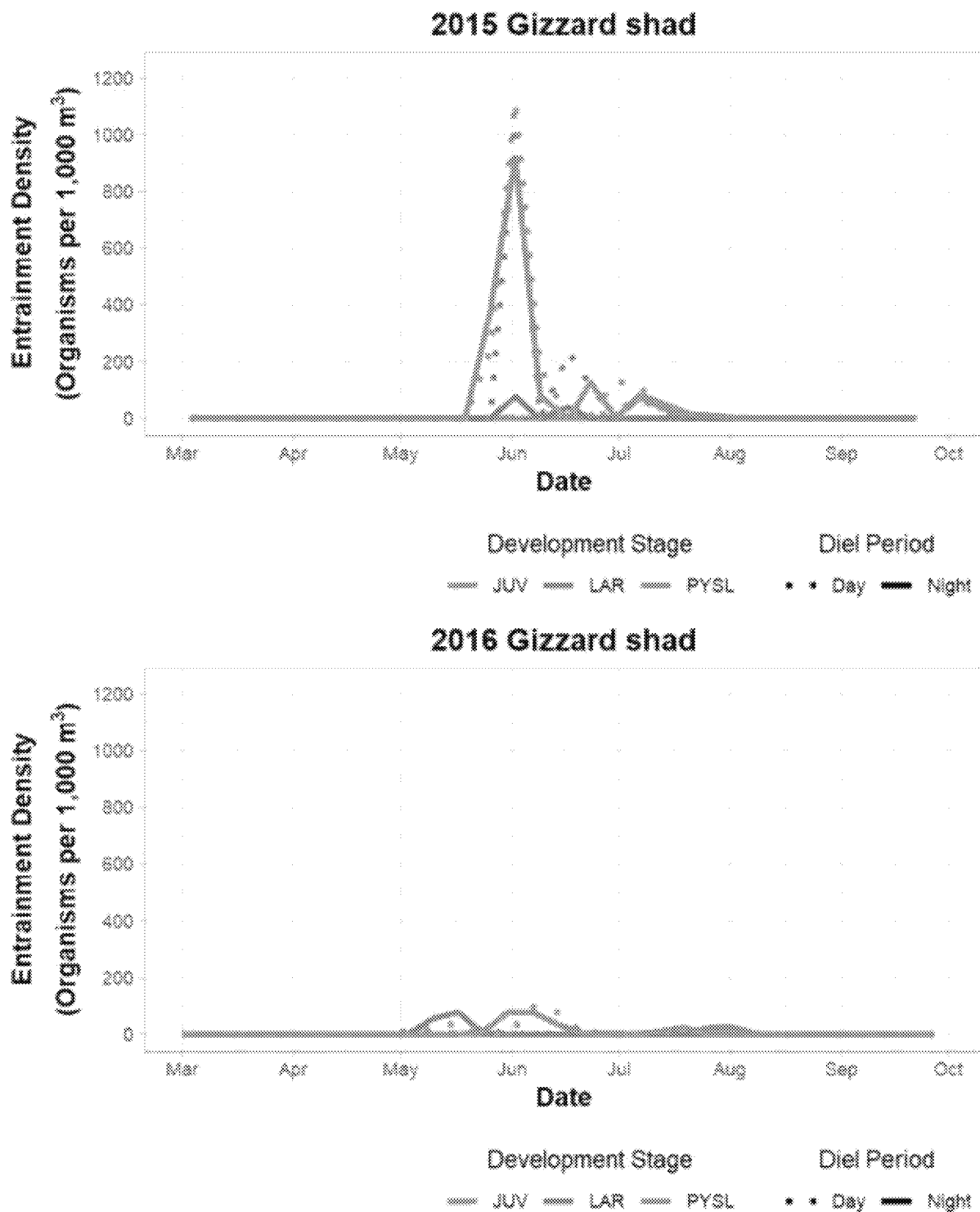
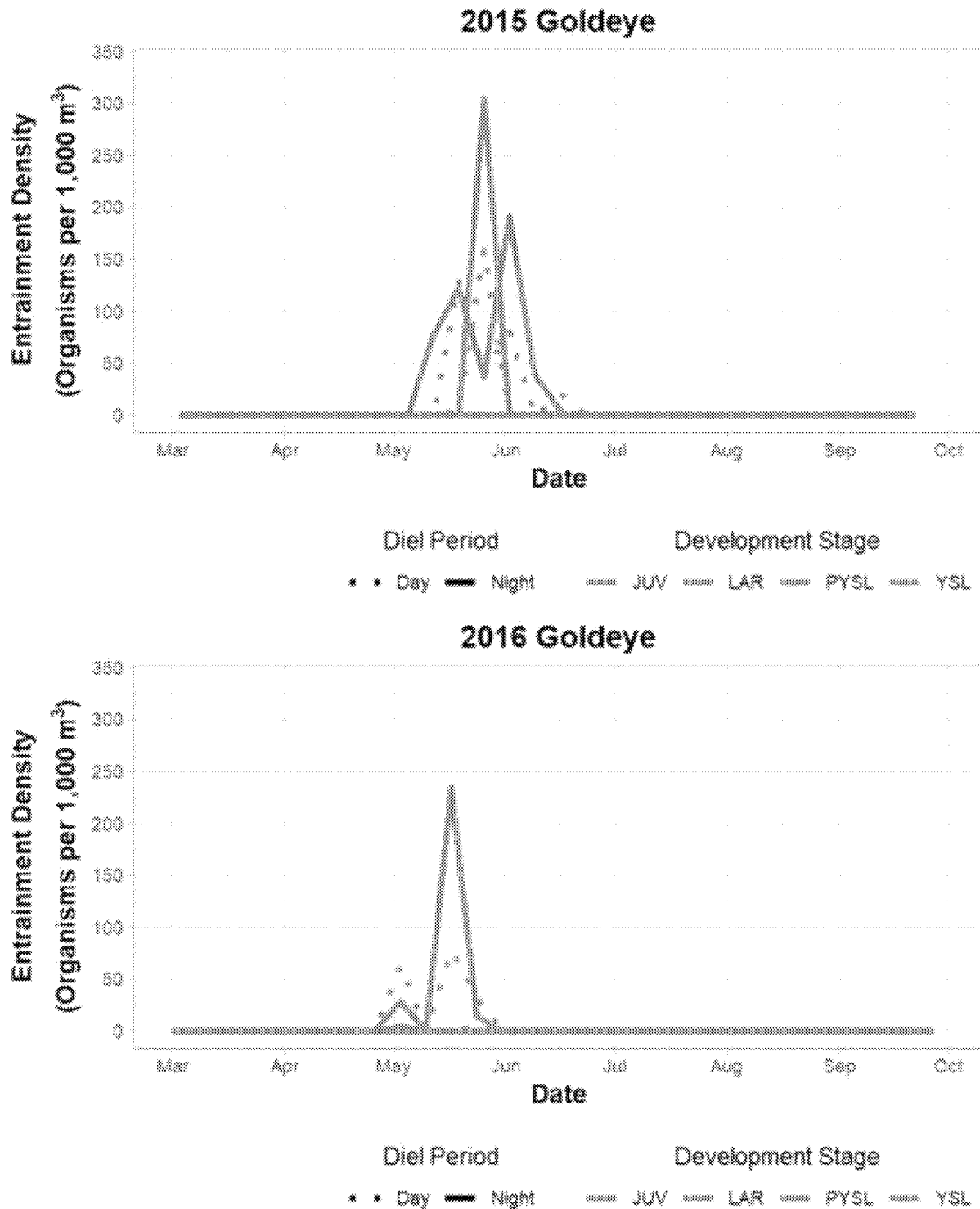


Figure 9 C-14 Mean Daytime and Nighttime Entrainment of Gizzard Shad by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-15 Mean Daytime and Nighttime Entrainment of Goldeye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

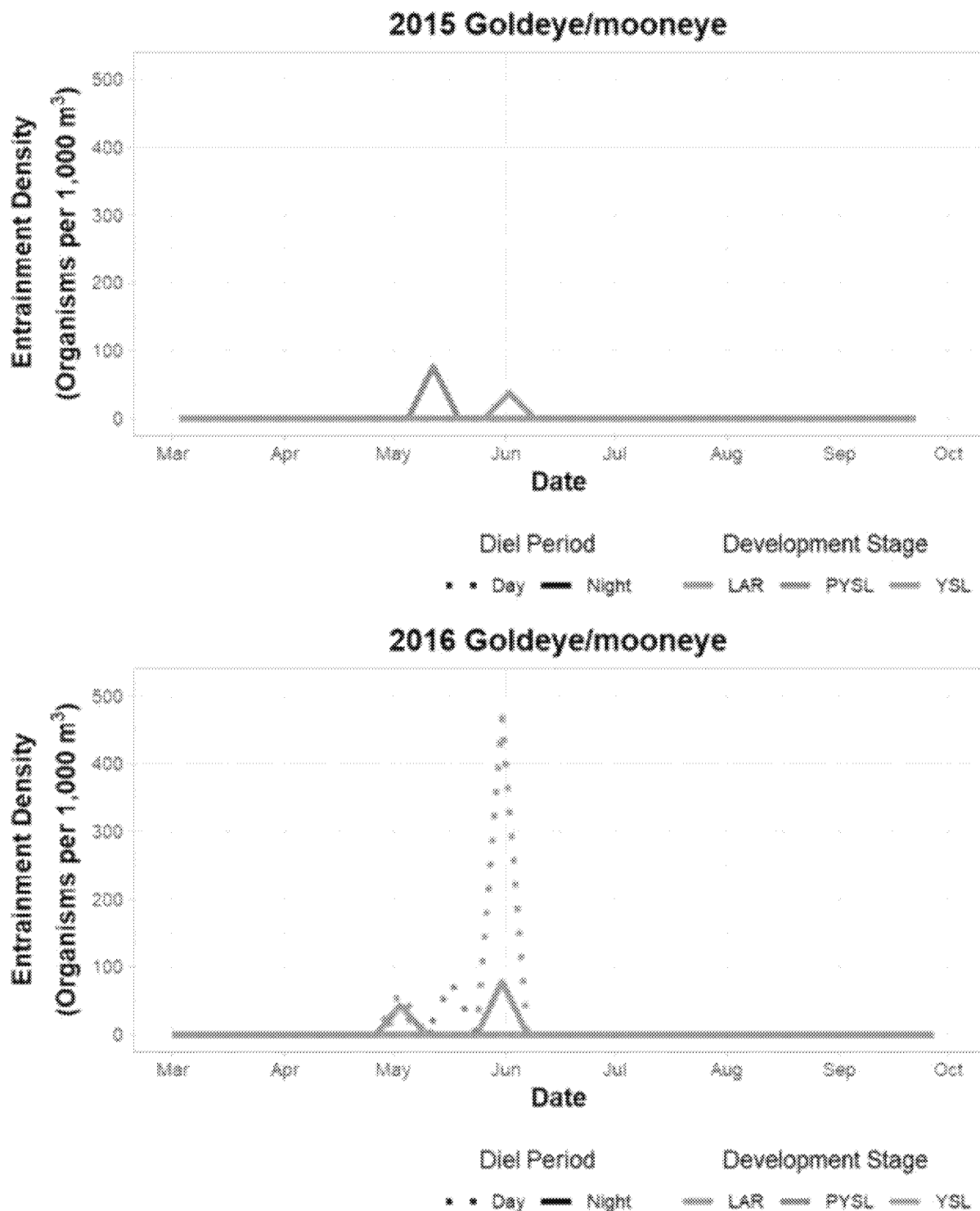


Figure 9 C-16 Mean Daytime and Nighttime Entrainment of Mooneyes (*Hiodon* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

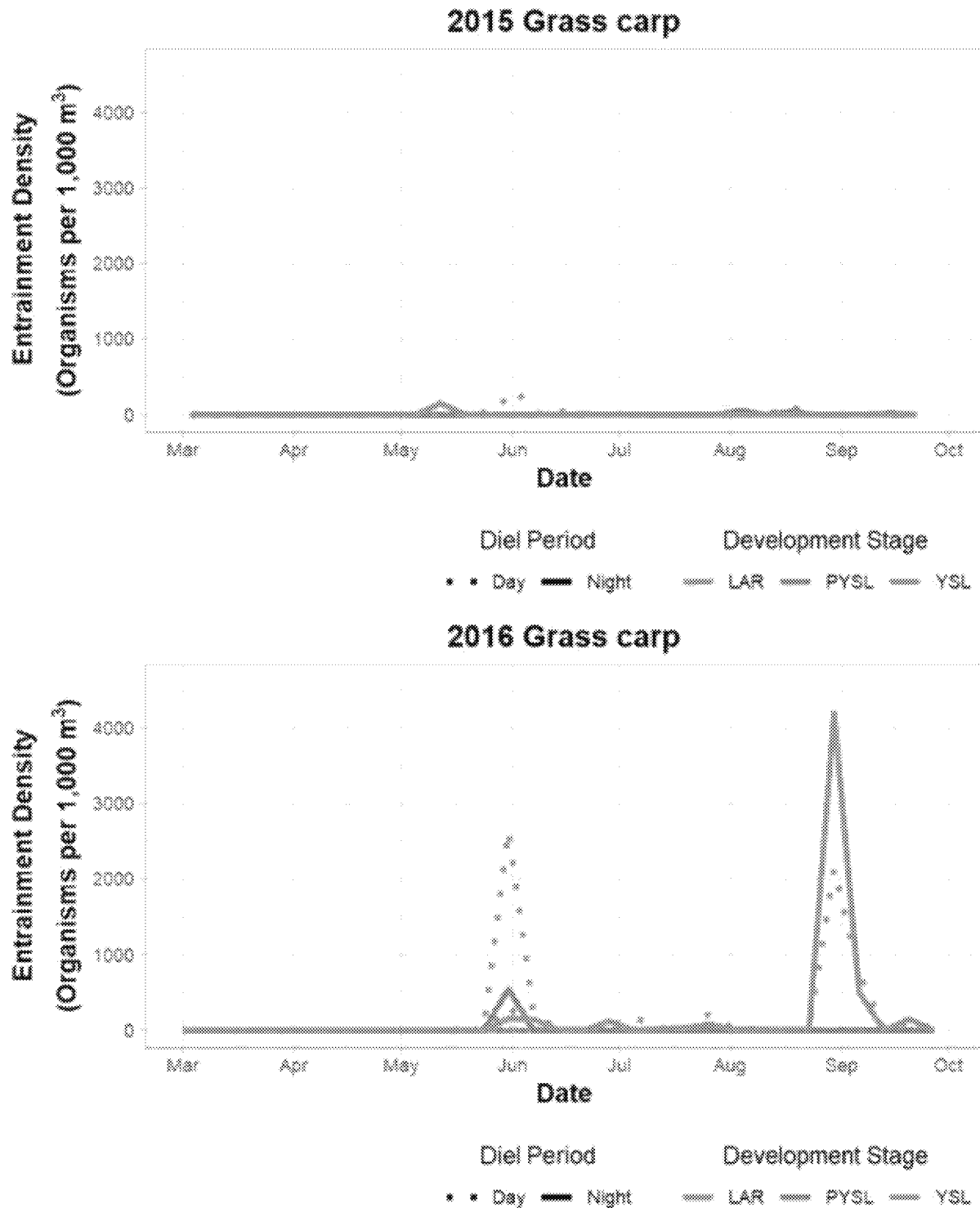


Figure 9 C-17 Mean Daytime and Nighttime Entrainment of Grass Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

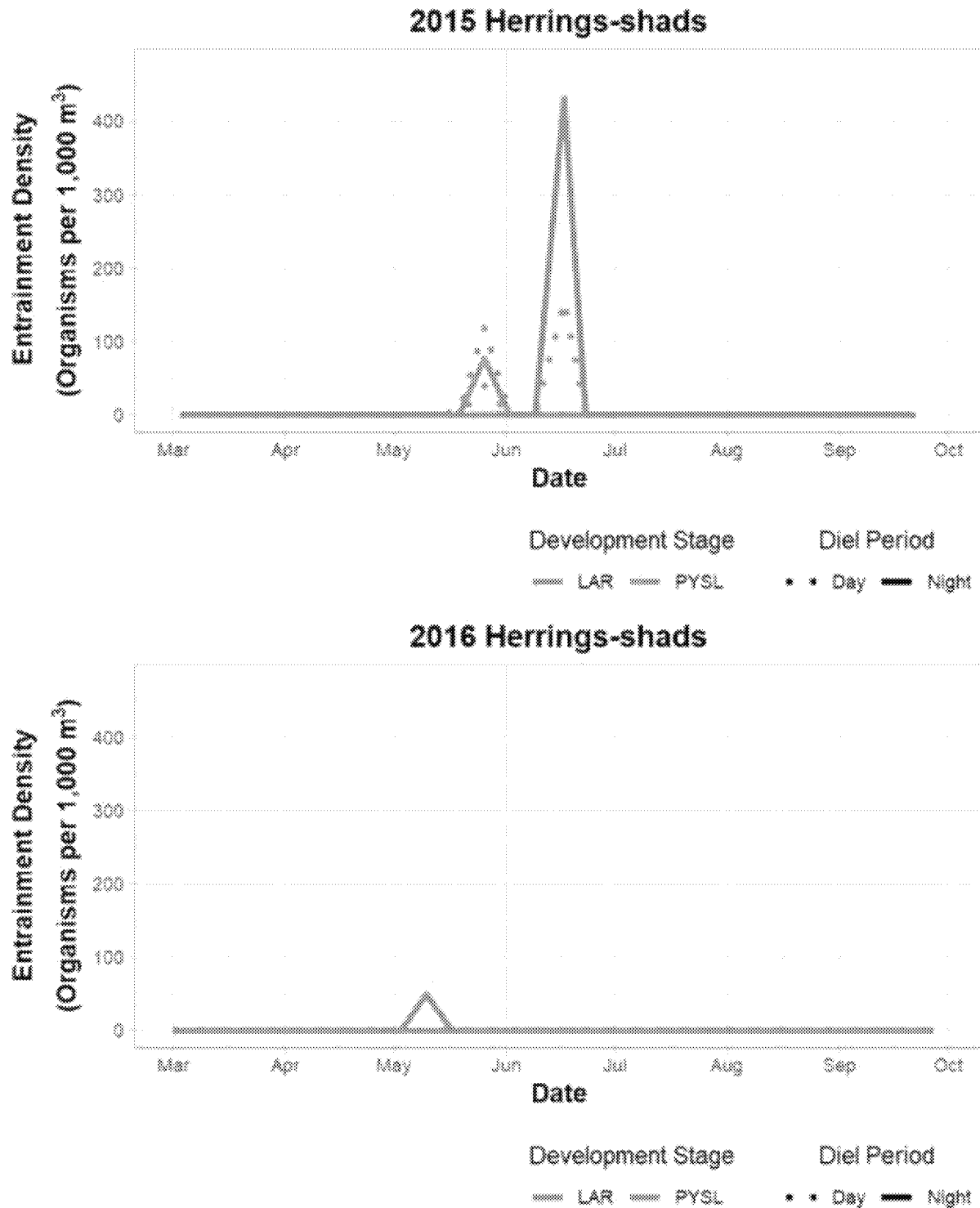
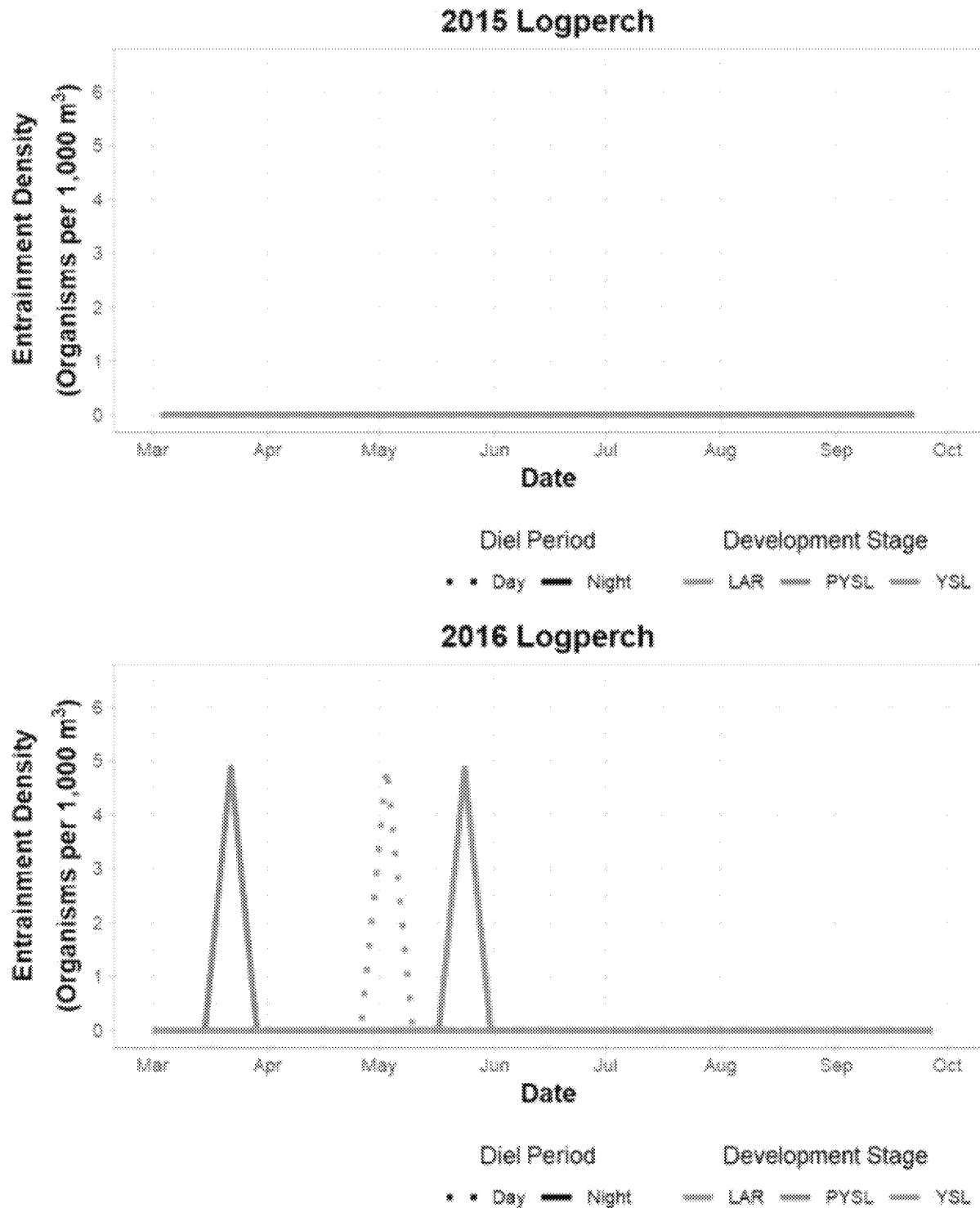


Figure 9 C-18 Mean Daytime and Nighttime Entrainment of Shads (*Dorosoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-19 Mean Daytime and Nighttime Entrainment of Loggerch by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

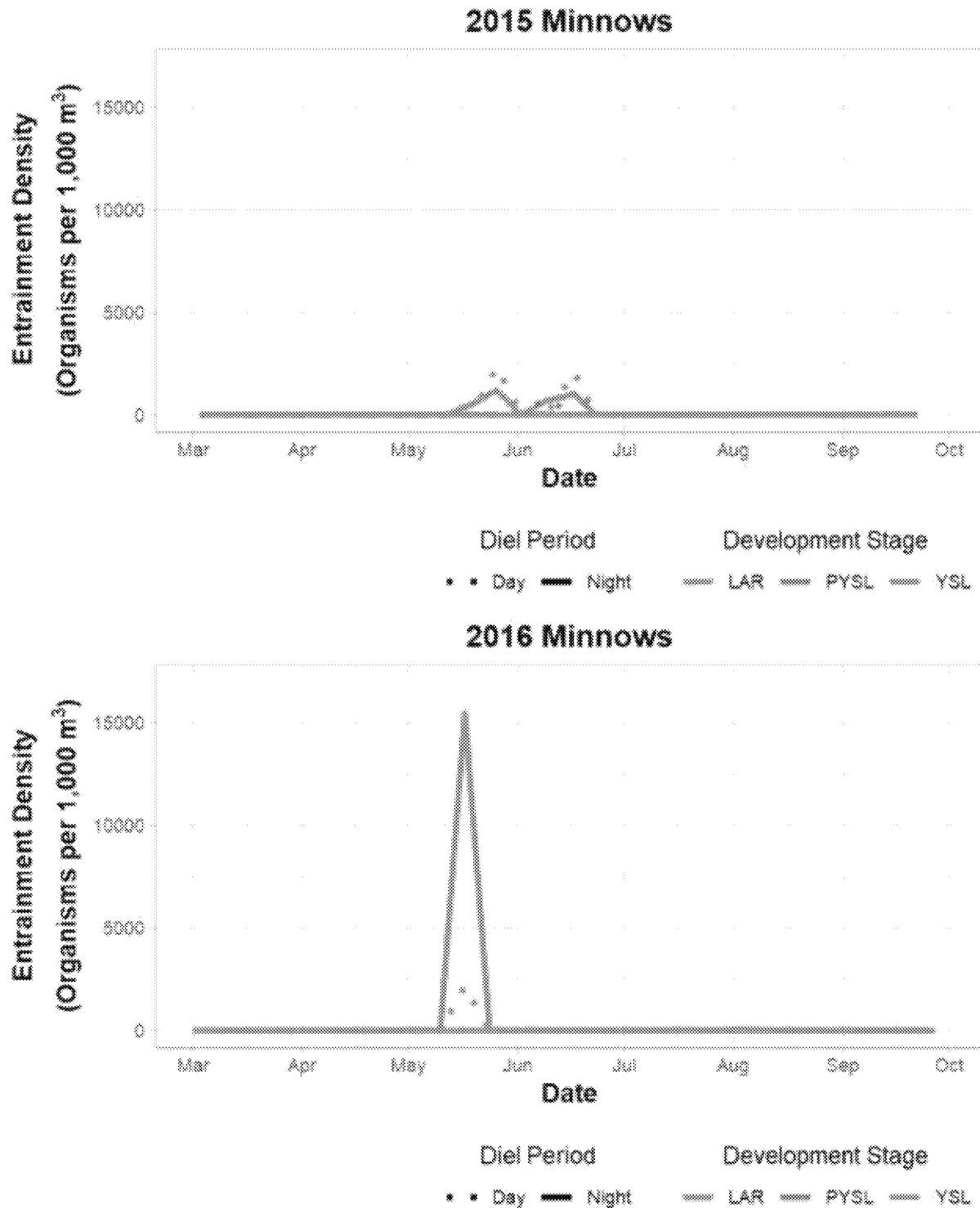


Figure 9 C-20 Mean Daytime and Nighttime Entrainment of Minnow Family (Cyprinidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

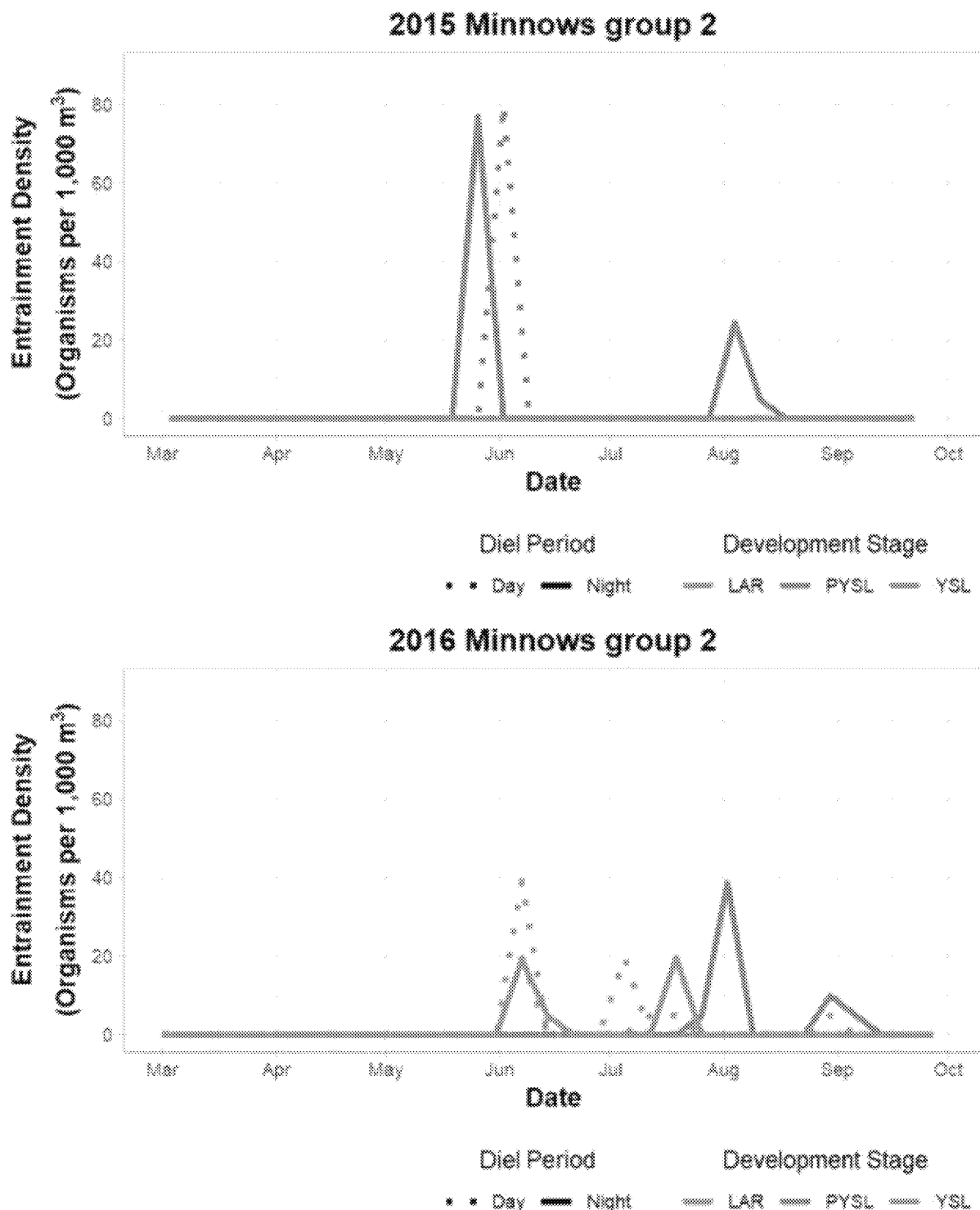


Figure 9 C-21 Mean Daytime and Nighttime Entrainment of Minnow Group 2 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



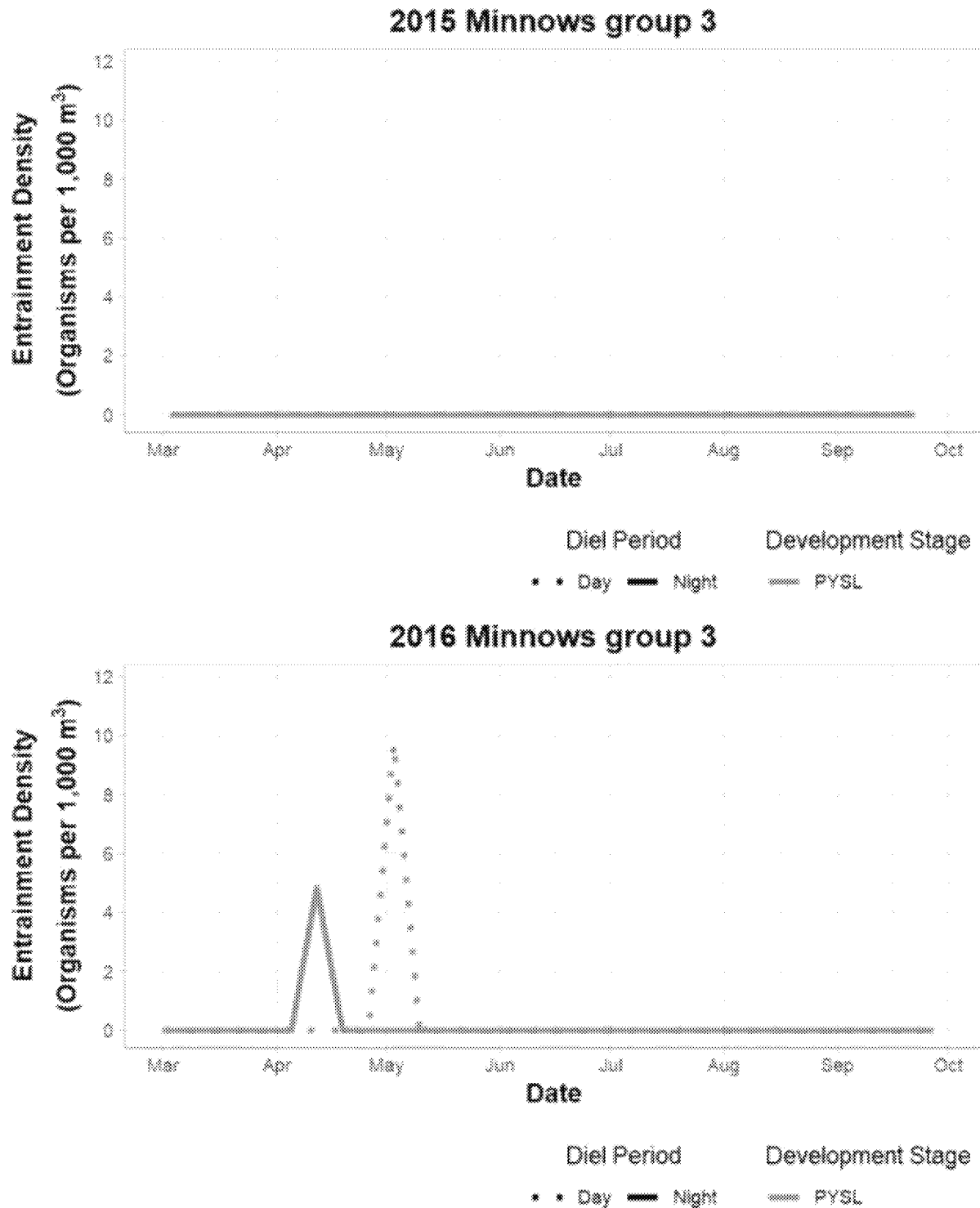


Figure 9 C-22 Mean Daytime and Nighttime Entrainment of Minnow Group 3 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

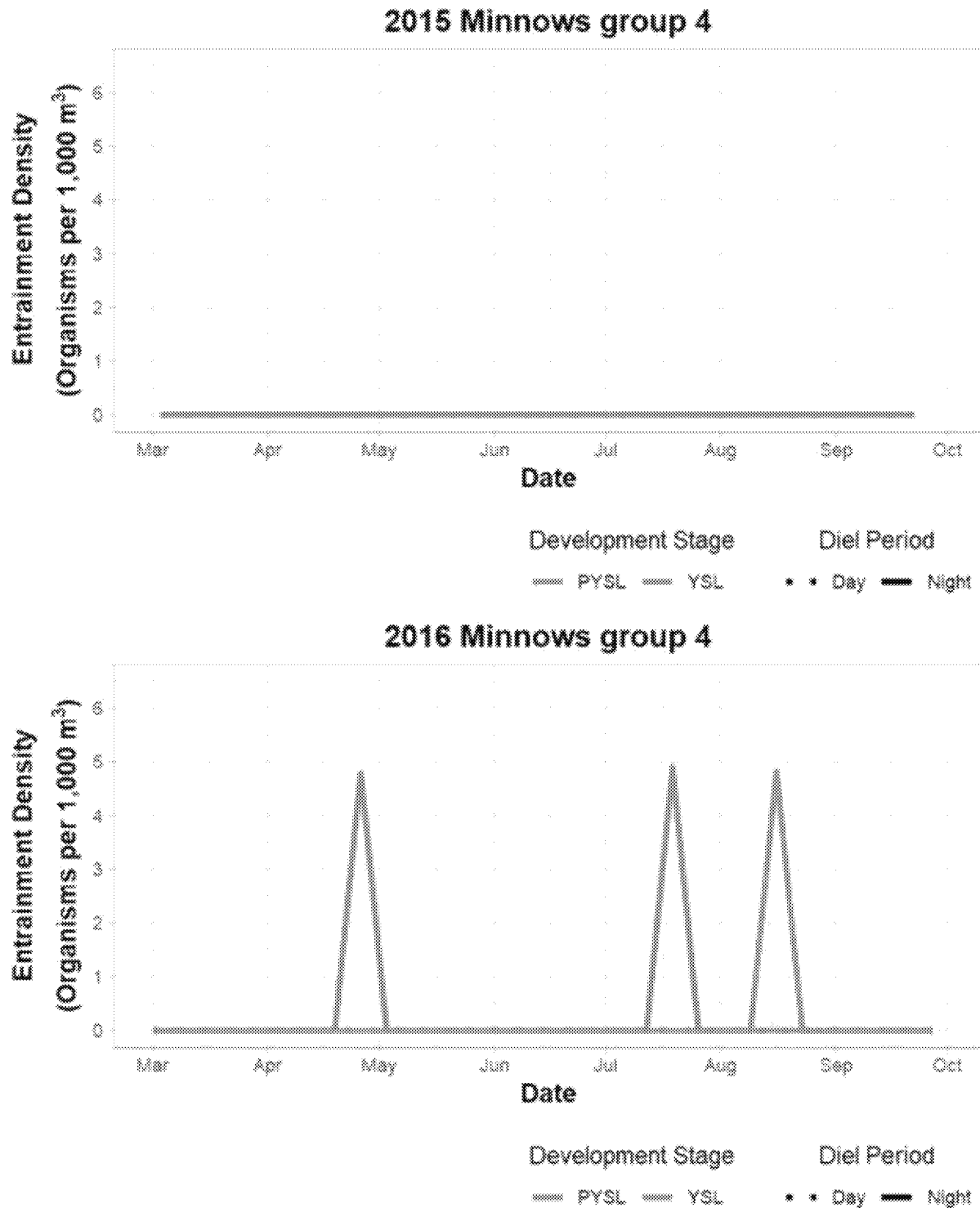


Figure 9 C-23 Mean Daytime and Nighttime Entrainment of Minnow Group 4 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

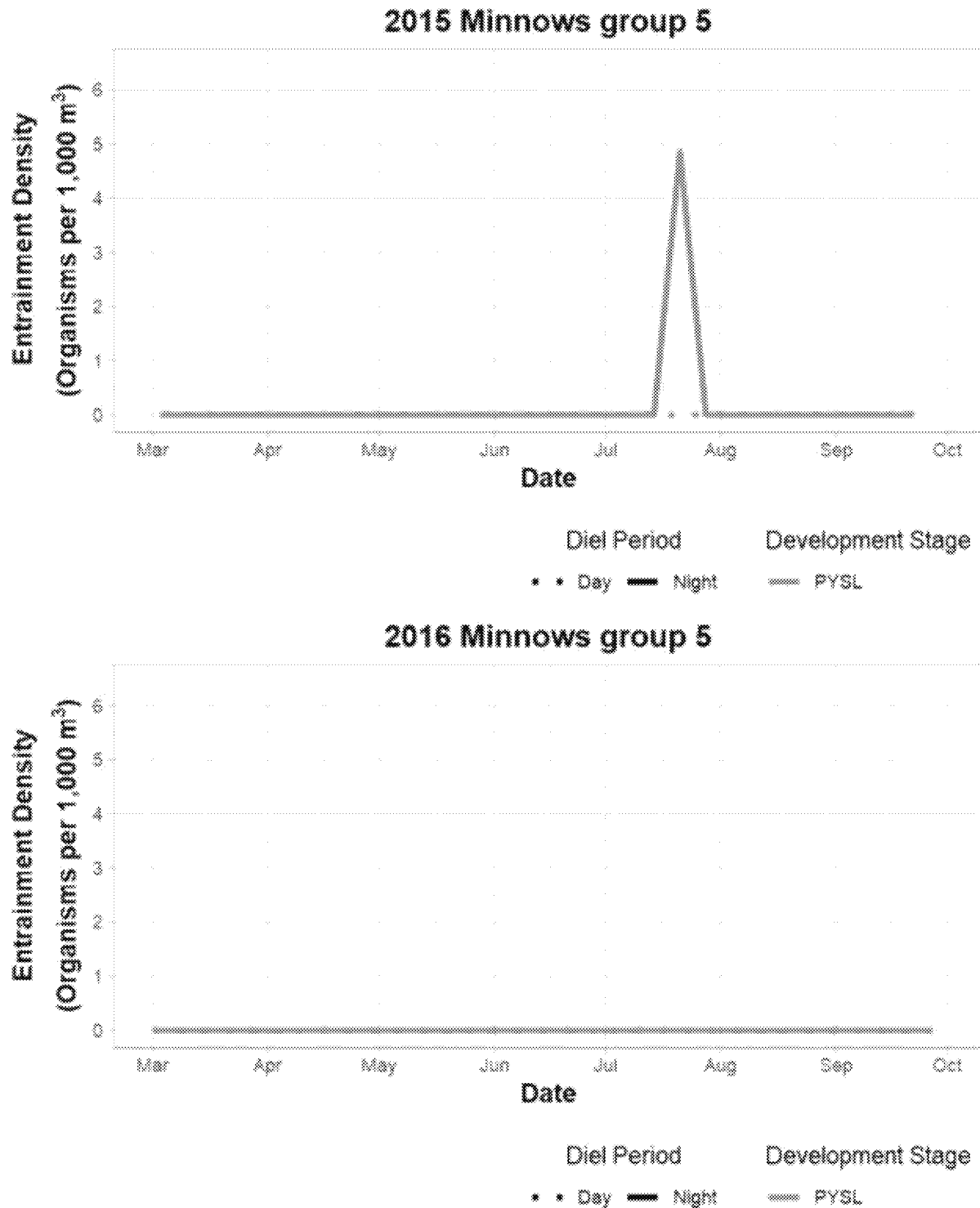


Figure 9 C-24 Mean Daytime and Nighttime Entrainment of Minnow Group 5 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

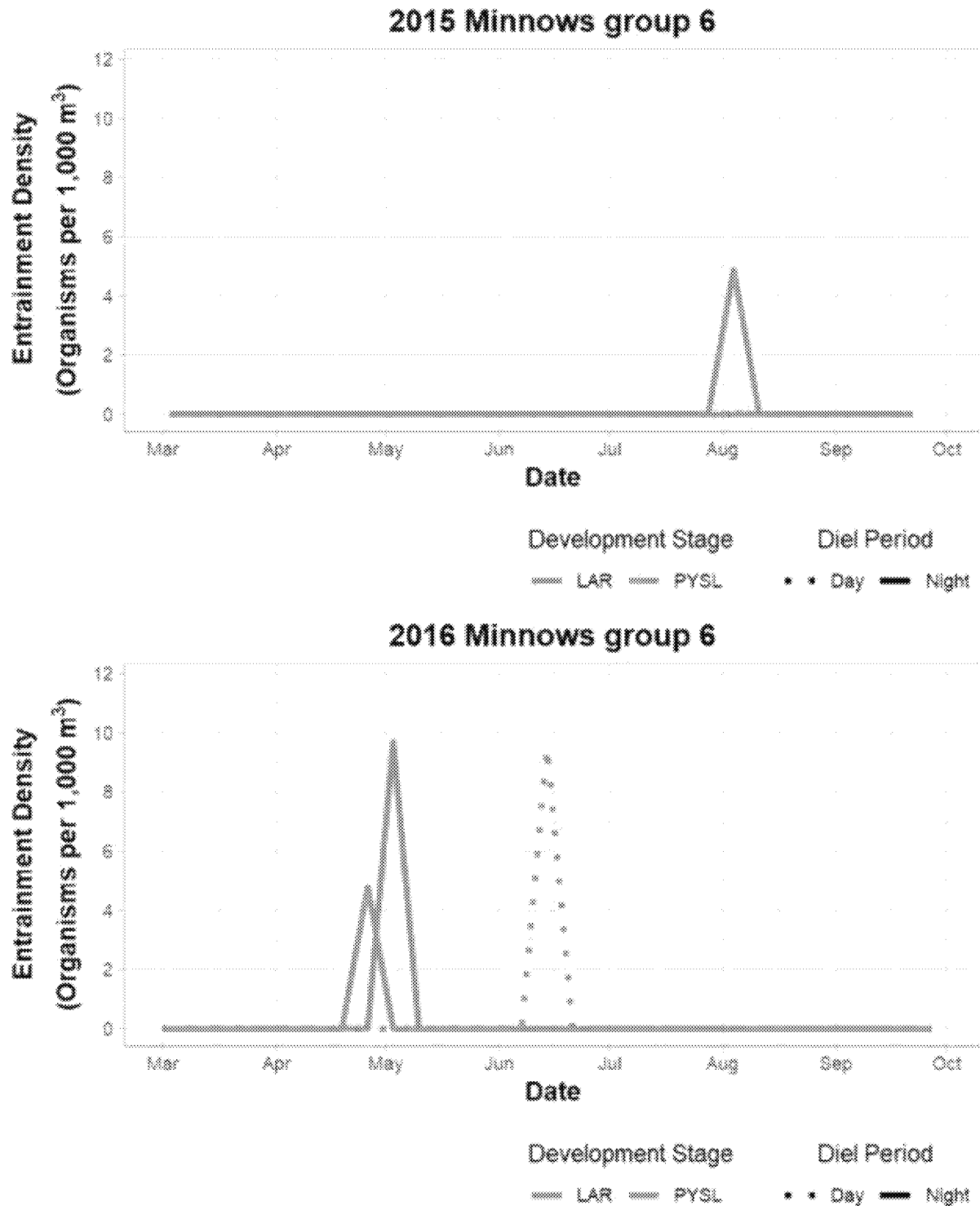


Figure 9 C-25 Mean Daytime and Nighttime Entrainment of Minnow Group 6 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

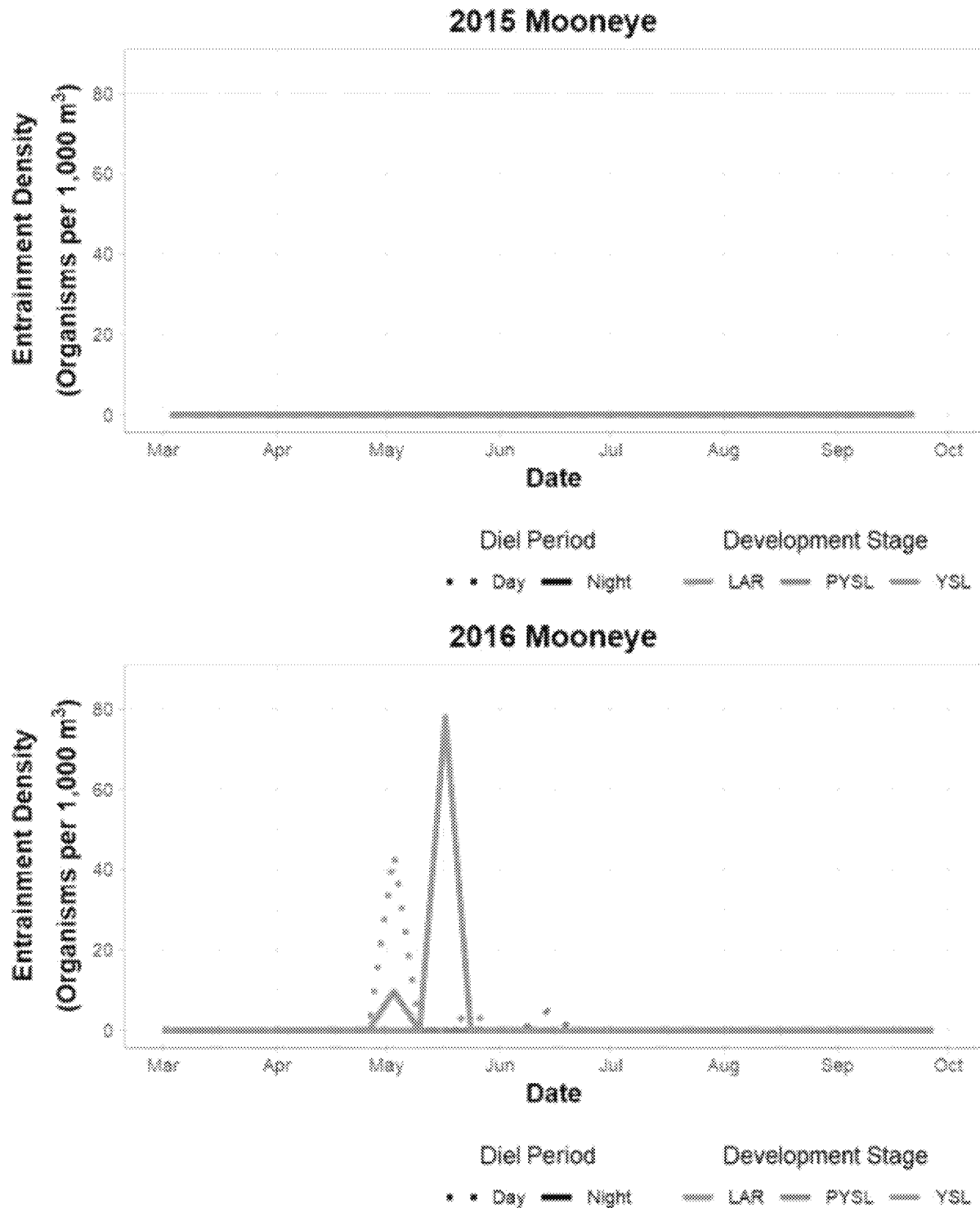


Figure 9 C-26 Mean Daytime and Nighttime Entrainment of Mooneye by Development Stages  
Collected During 2015 and 2016 Sampling Conducted at the LEC.

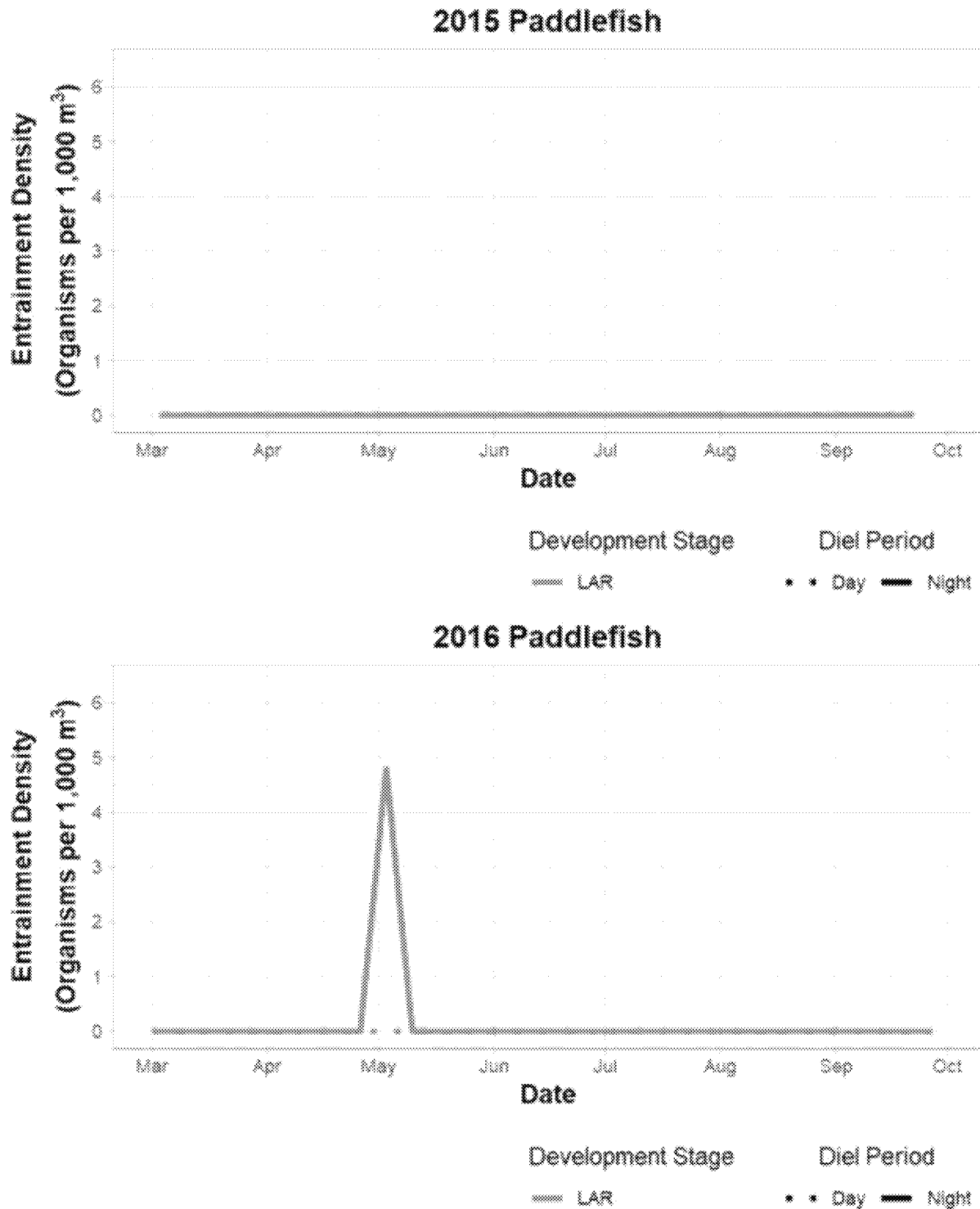


Figure 9 C-27 Mean Daytime and Nighttime Entrainment of Paddlefish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

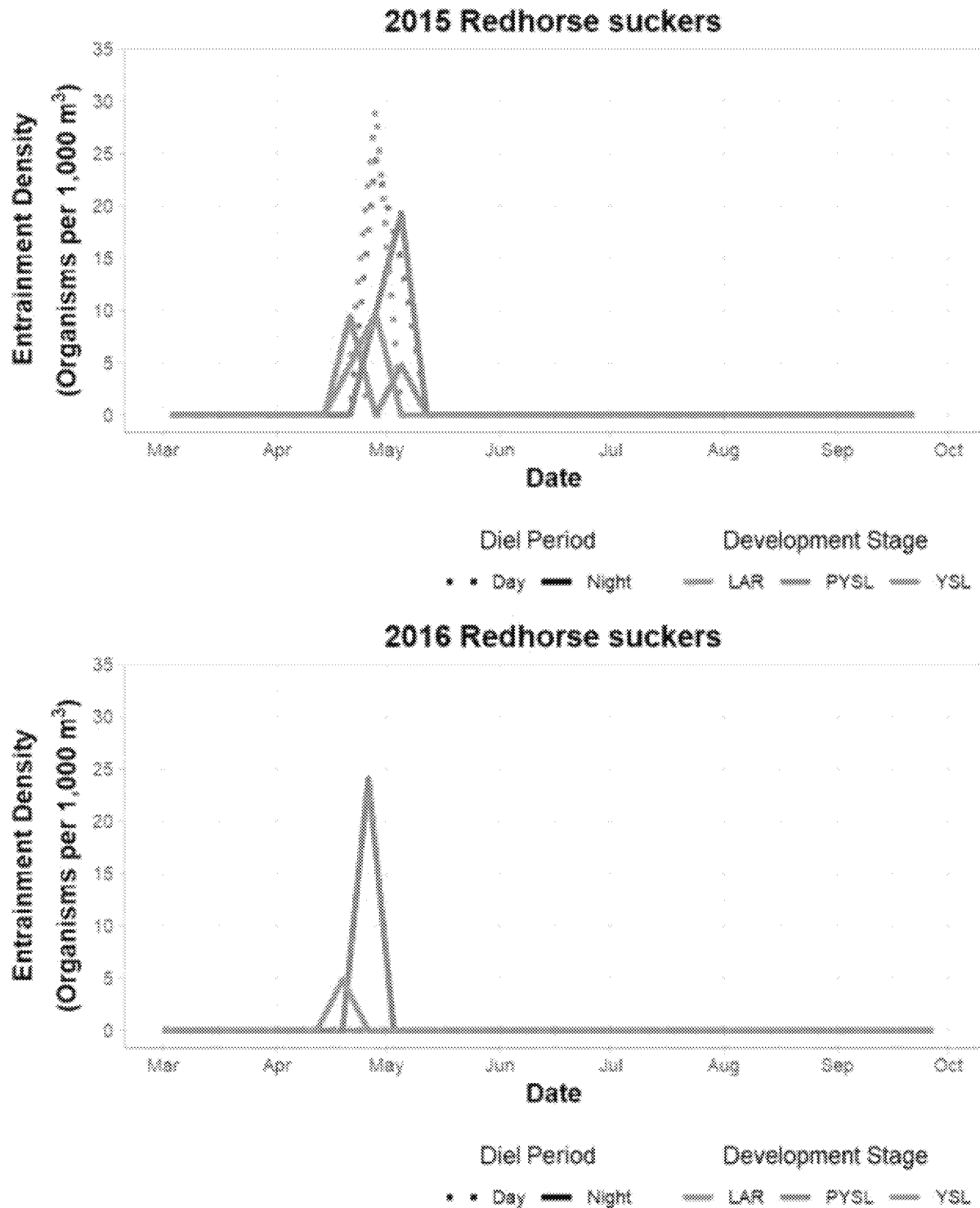
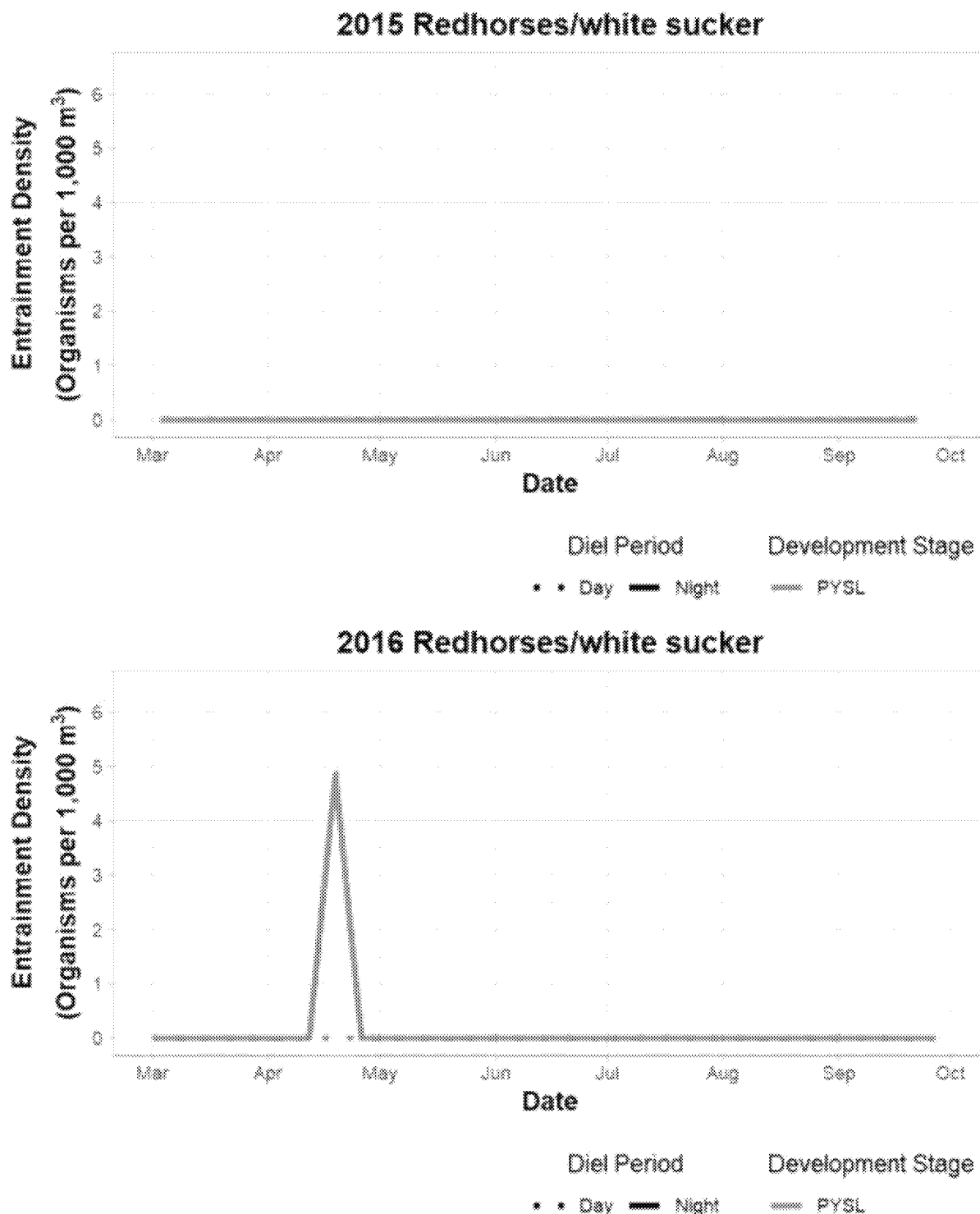


Figure 9 C-28 Mean Daytime and Nighttime Entrainment of Redhorses (*Moxostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-29 Mean Daytime and Nighttime Entrainment of Redhorses and Suckers (Subfamily Catostominae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



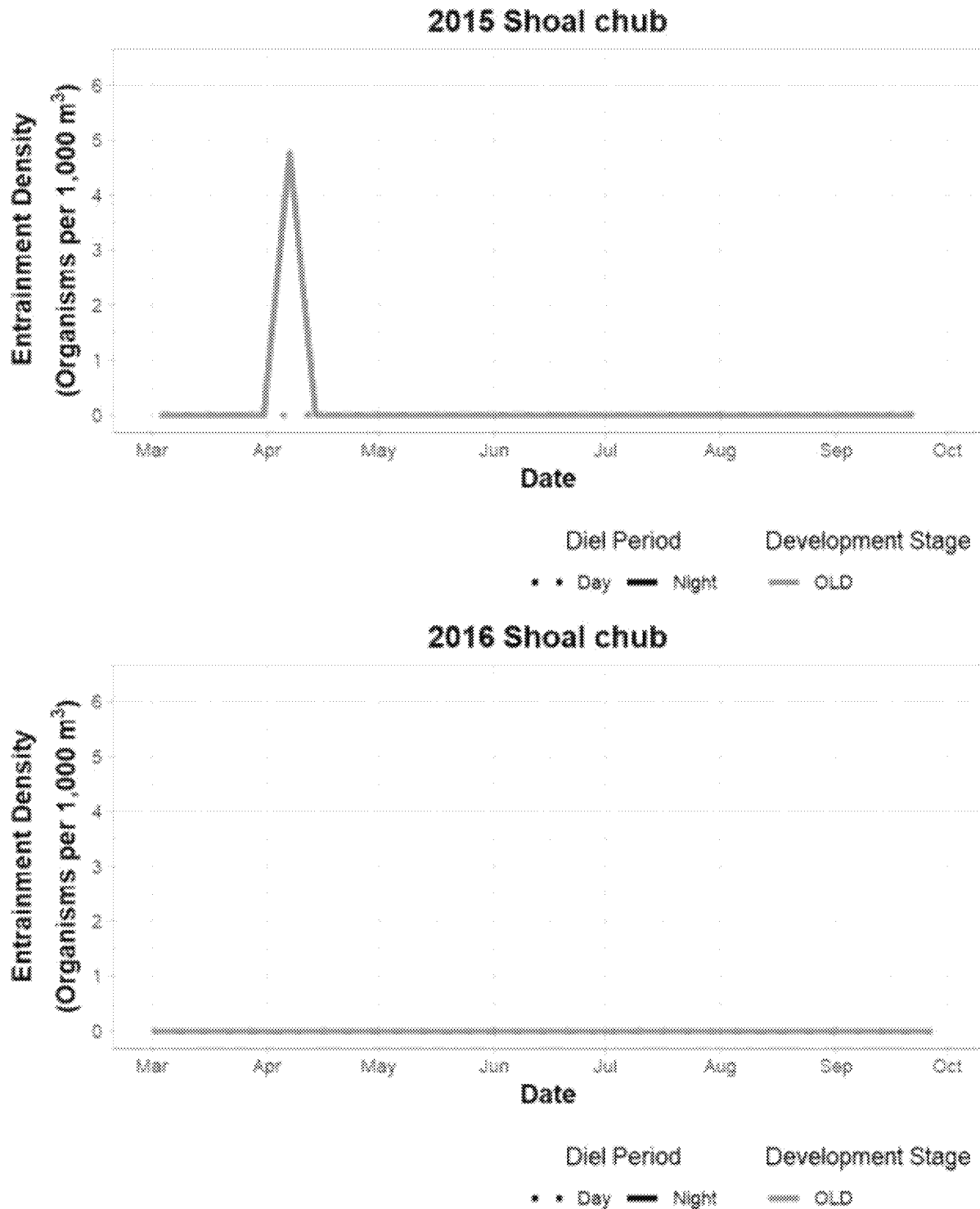


Figure 9 C-30 Mean Daytime and Nighttime Entrainment of Shoal Chub by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

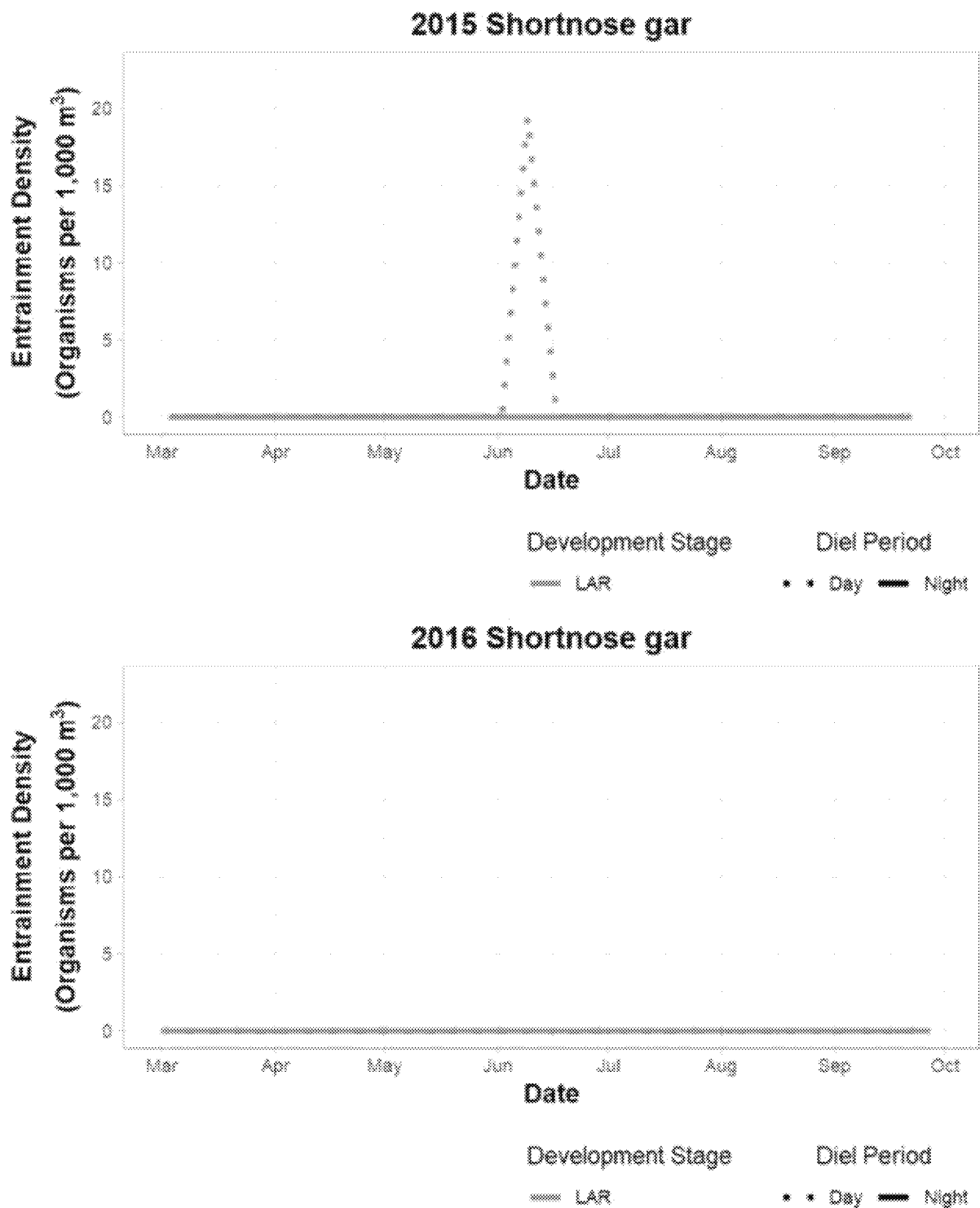
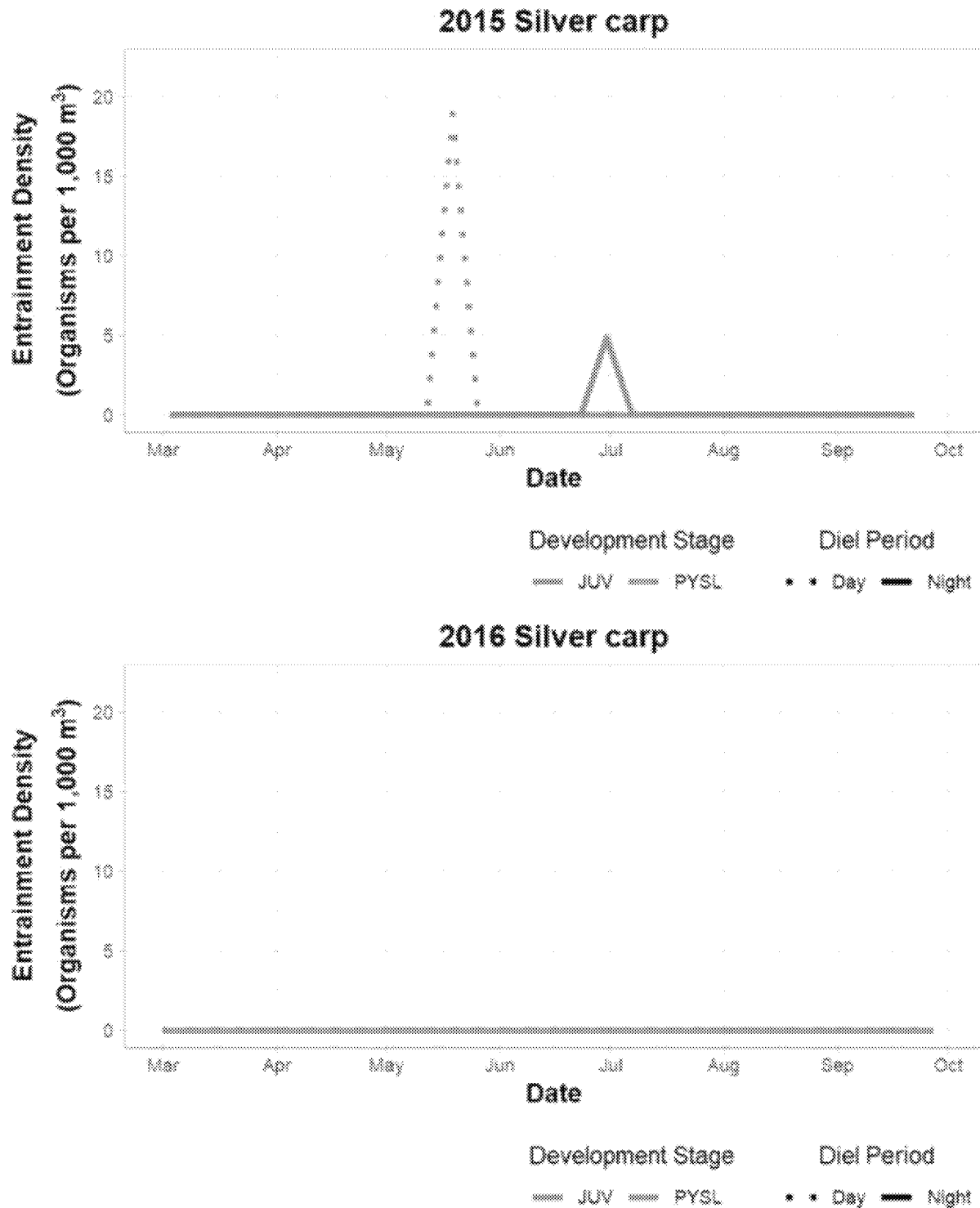


Figure 9 C-31 Mean Daytime and Nighttime Entrainment of Shortnose Gar by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 C-32 Mean Daytime and Nighttime Entrainment of Silver Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

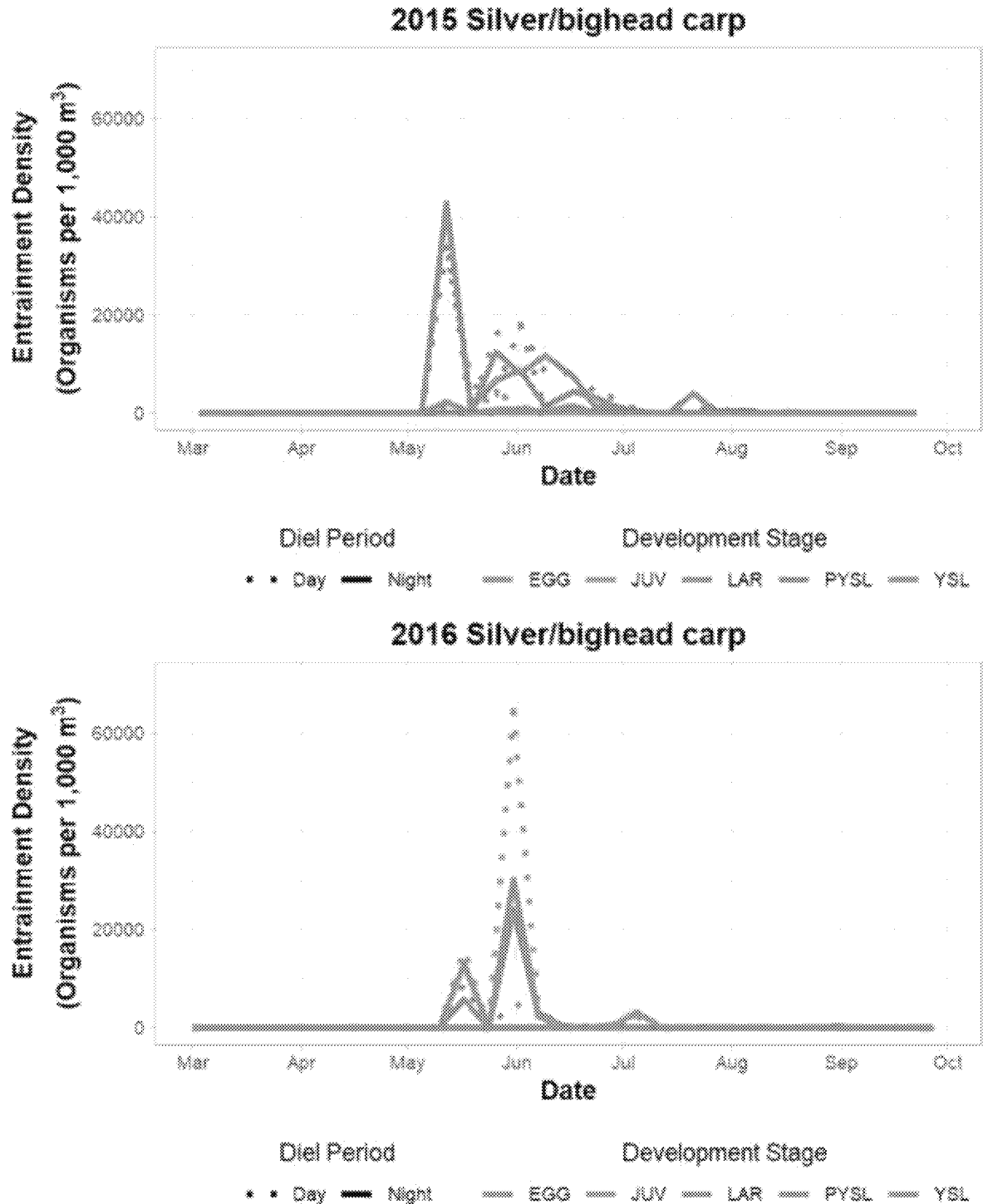


Figure 9 C-33 Mean Daytime and Nighttime Entrainment of Silver Carp and Bighead Carp (*Hypophthalmichthys* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

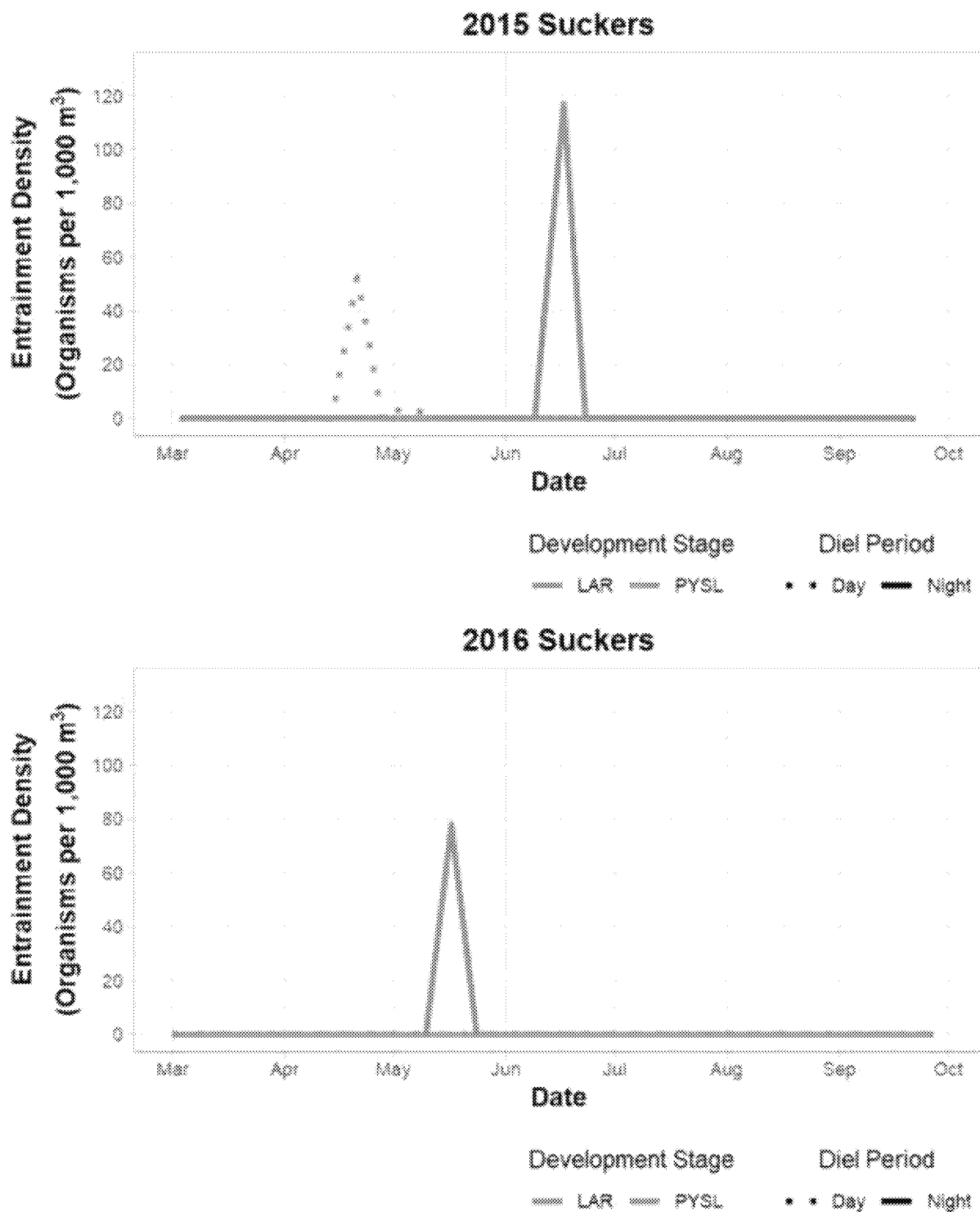


Figure 9 C-34 Mean Daytime and Nighttime Entrainment of Sucker Family (Catostomidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

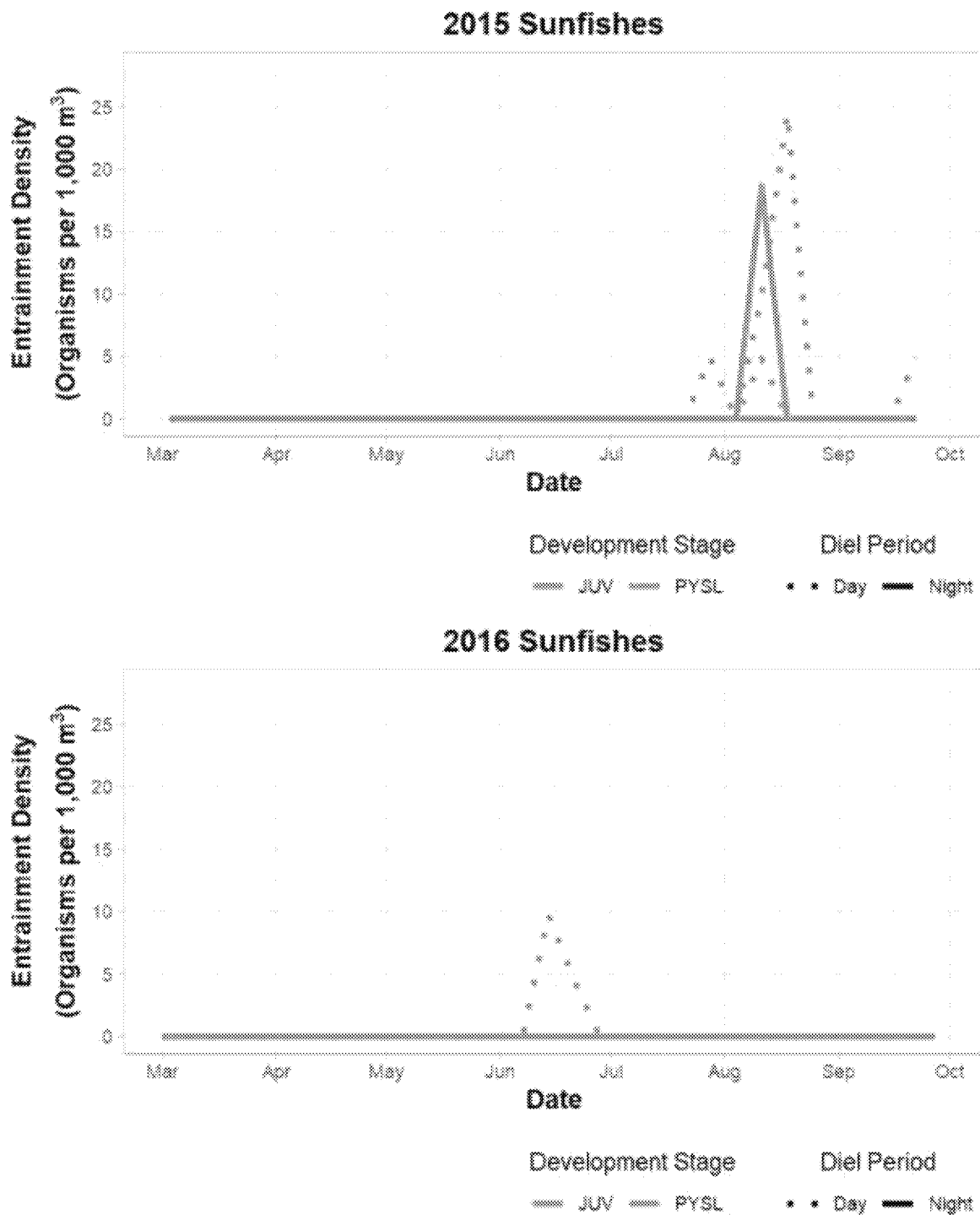


Figure 9 C-35 Mean Daytime and Nighttime Entrainment of Sunfish Family (Centrarchidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

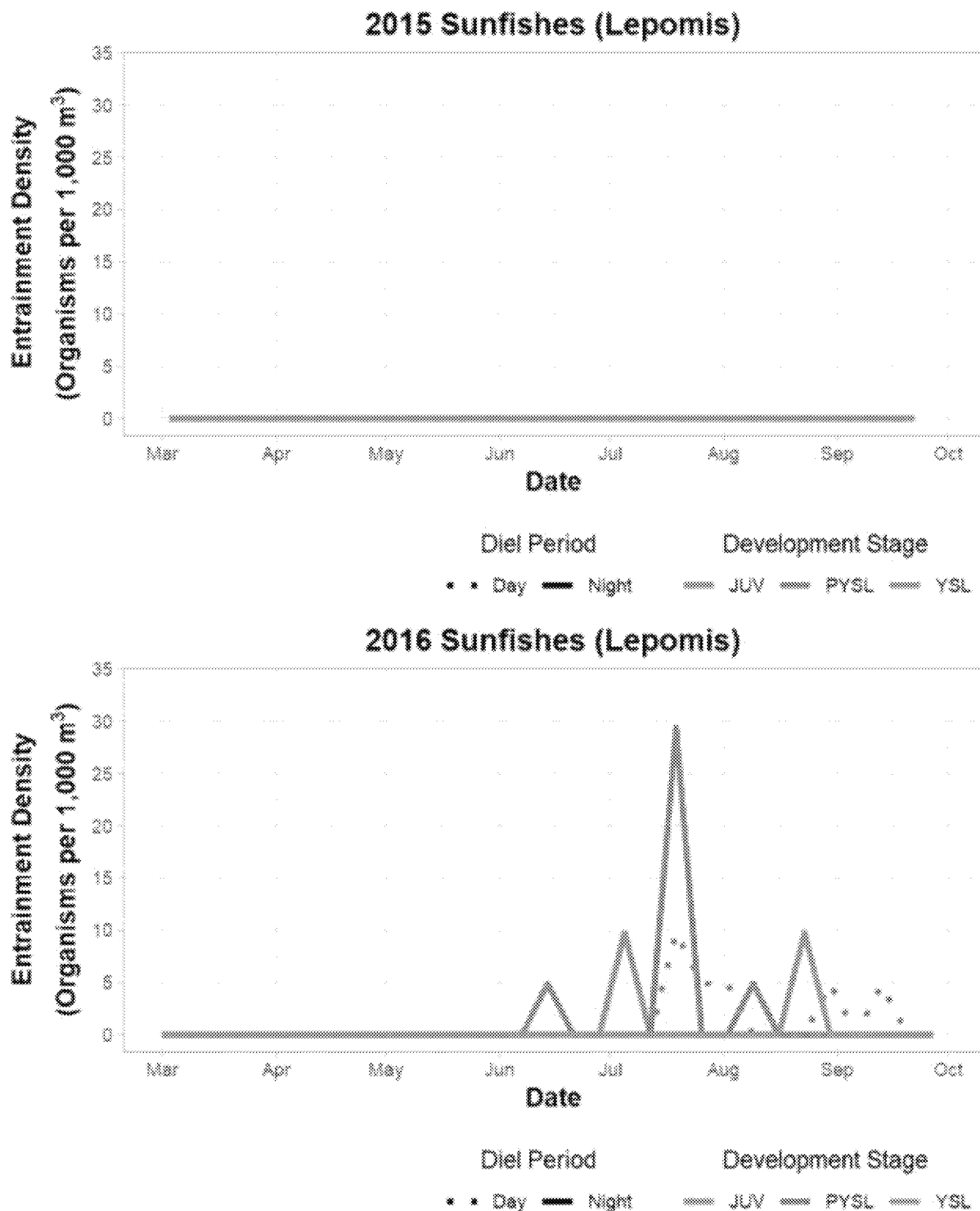


Figure 9 C-36 Mean Daytime and Nighttime Entrainment of Sunfishes (*Lepomis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

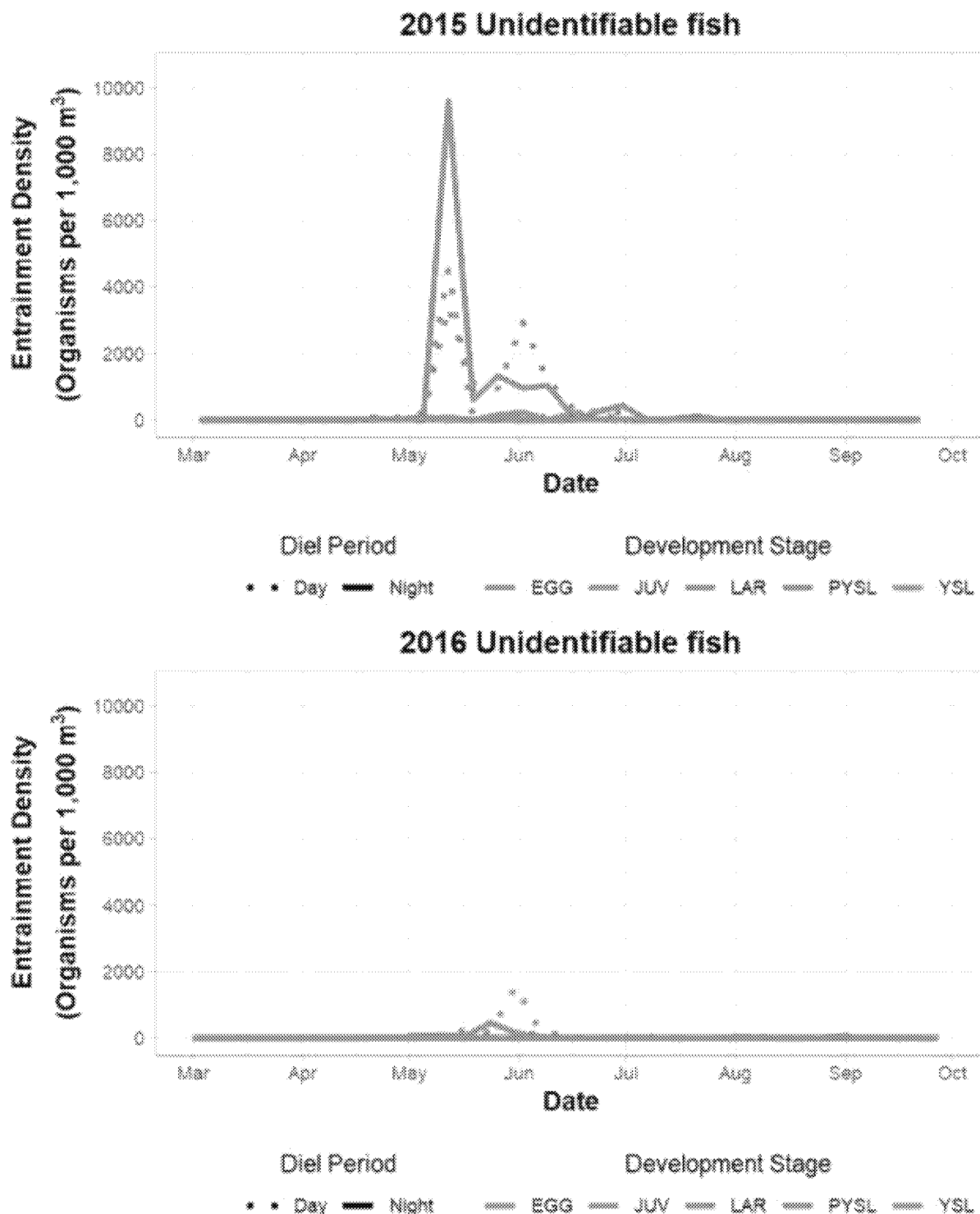


Figure 9 C-37 Mean Daytime and Nighttime Entrainment of Unidentifiable Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



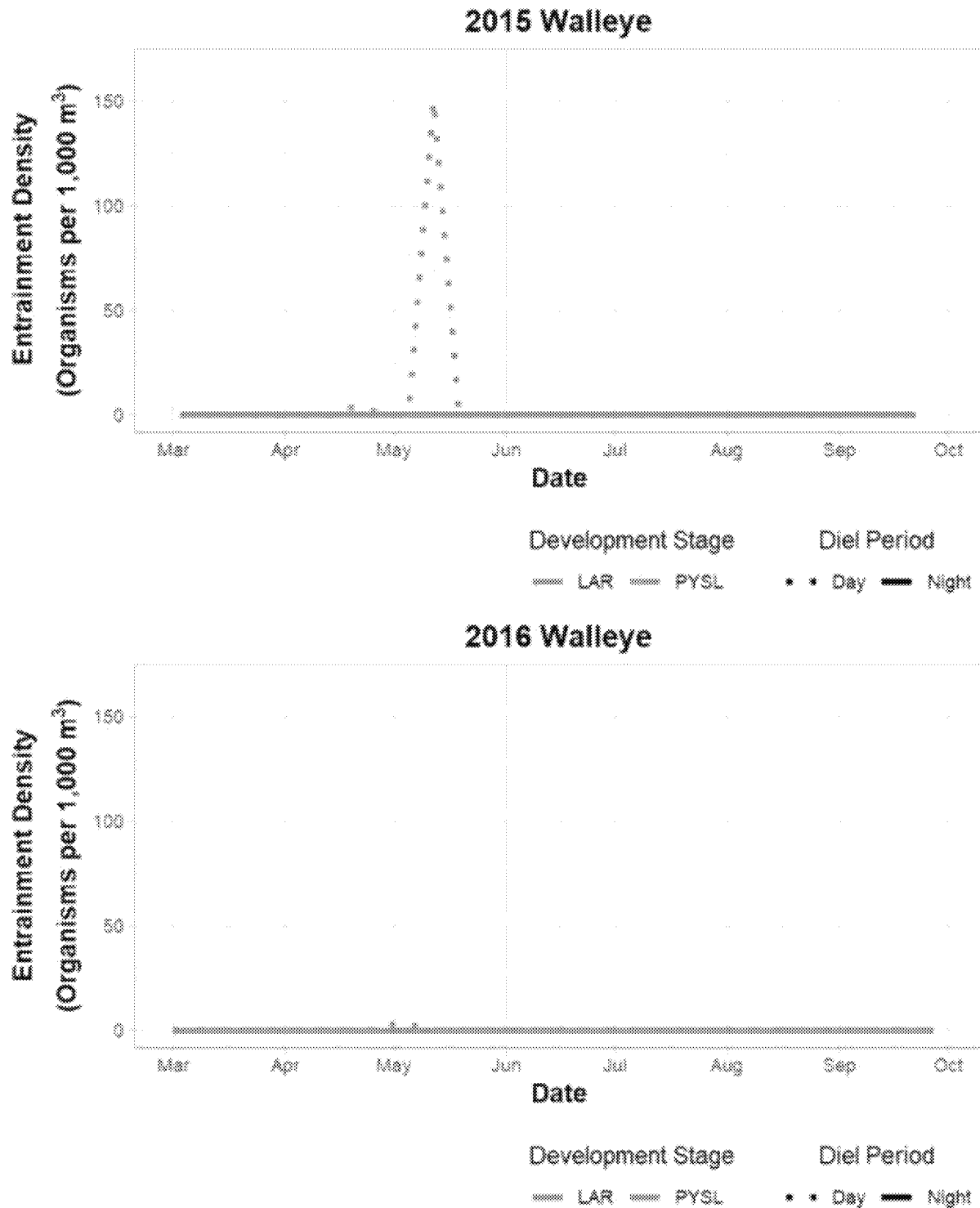


Figure 9 C-38 Mean Daytime and Nighttime Entrainment of Walleye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

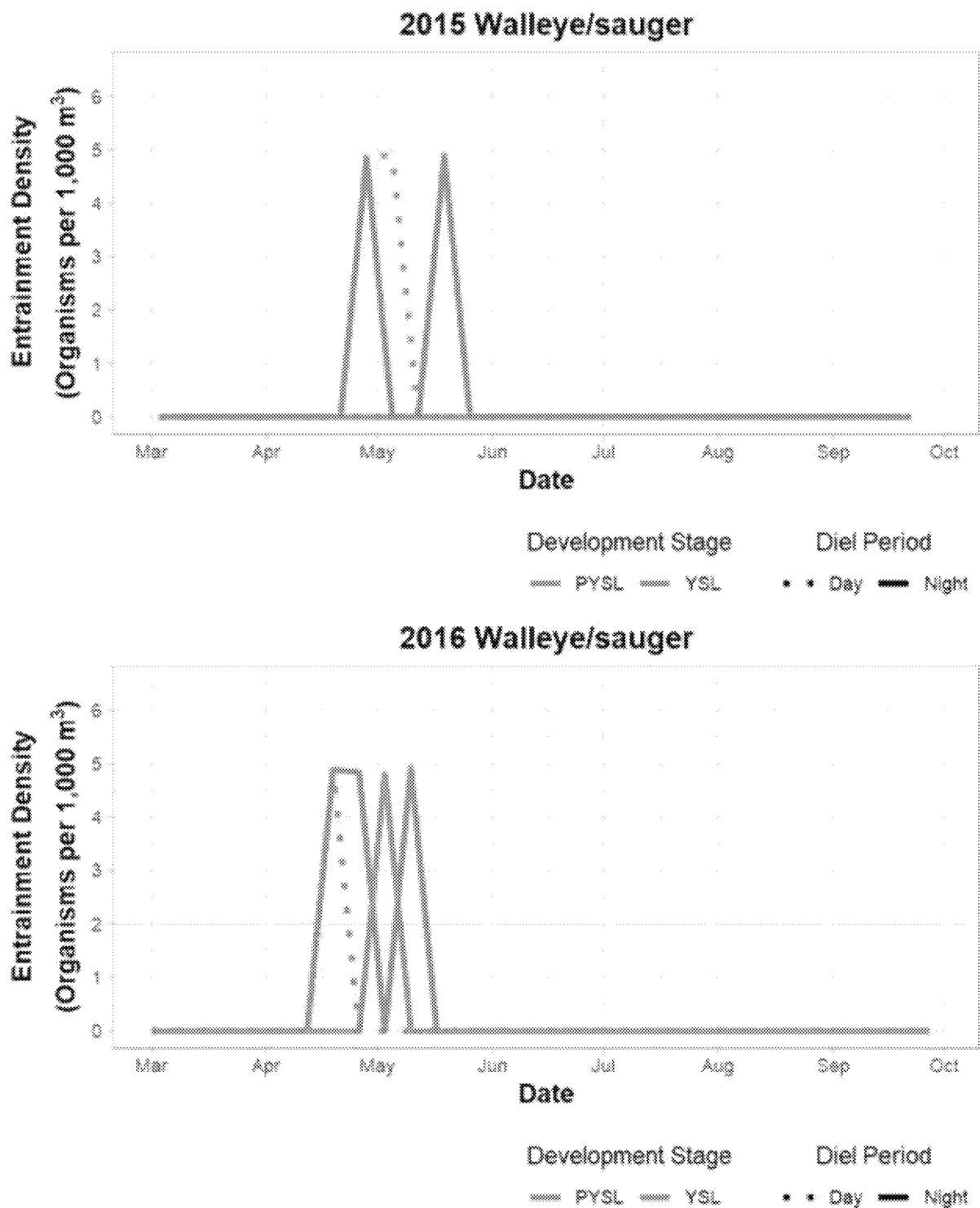


Figure 9 C-39 Mean Daytime and Nighttime Entrainment of Walleye and Sauger (*Sander sp.*) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

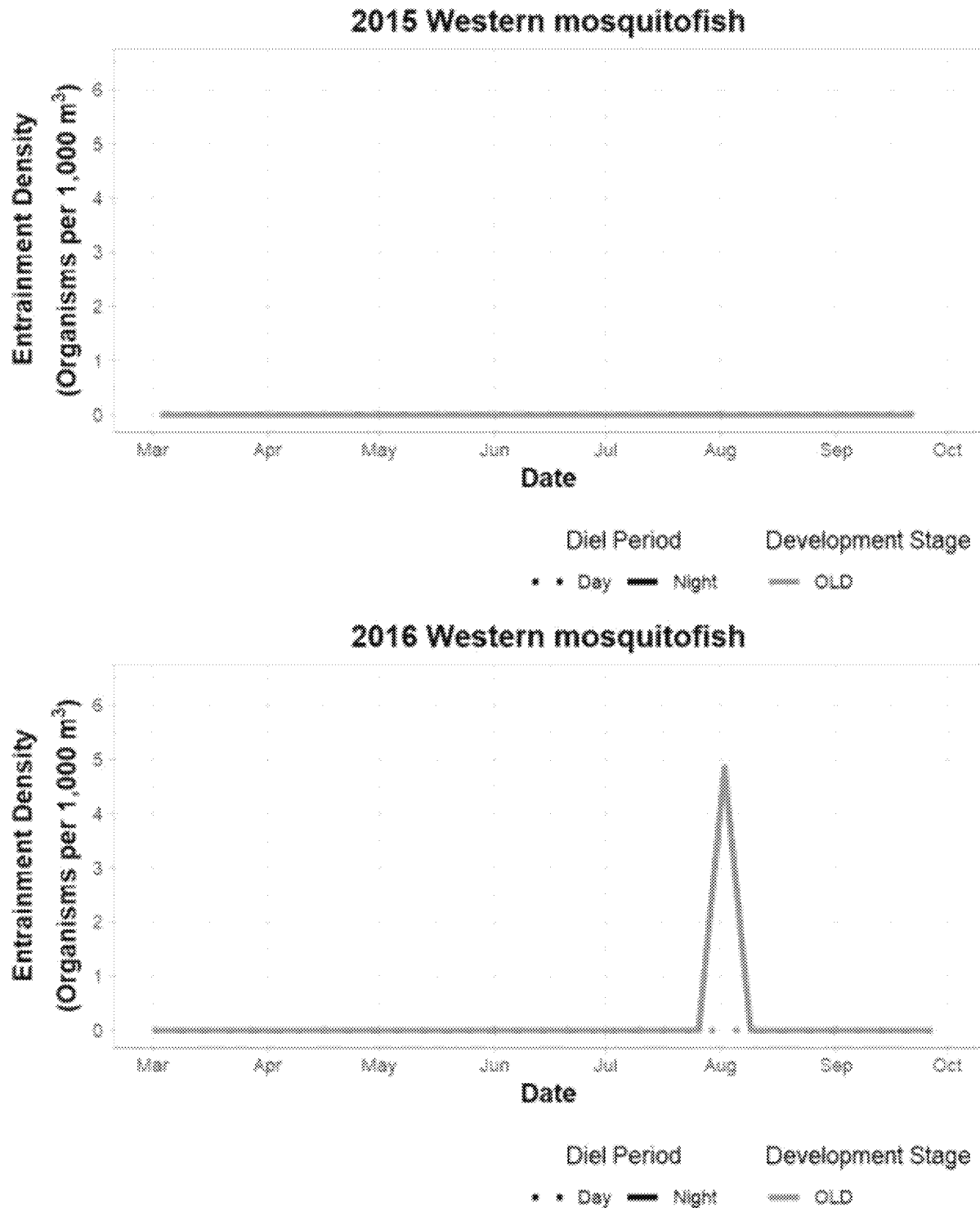


Figure 9 C-40 Mean Daytime and Nighttime Entrainment of Western Mosquitofish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

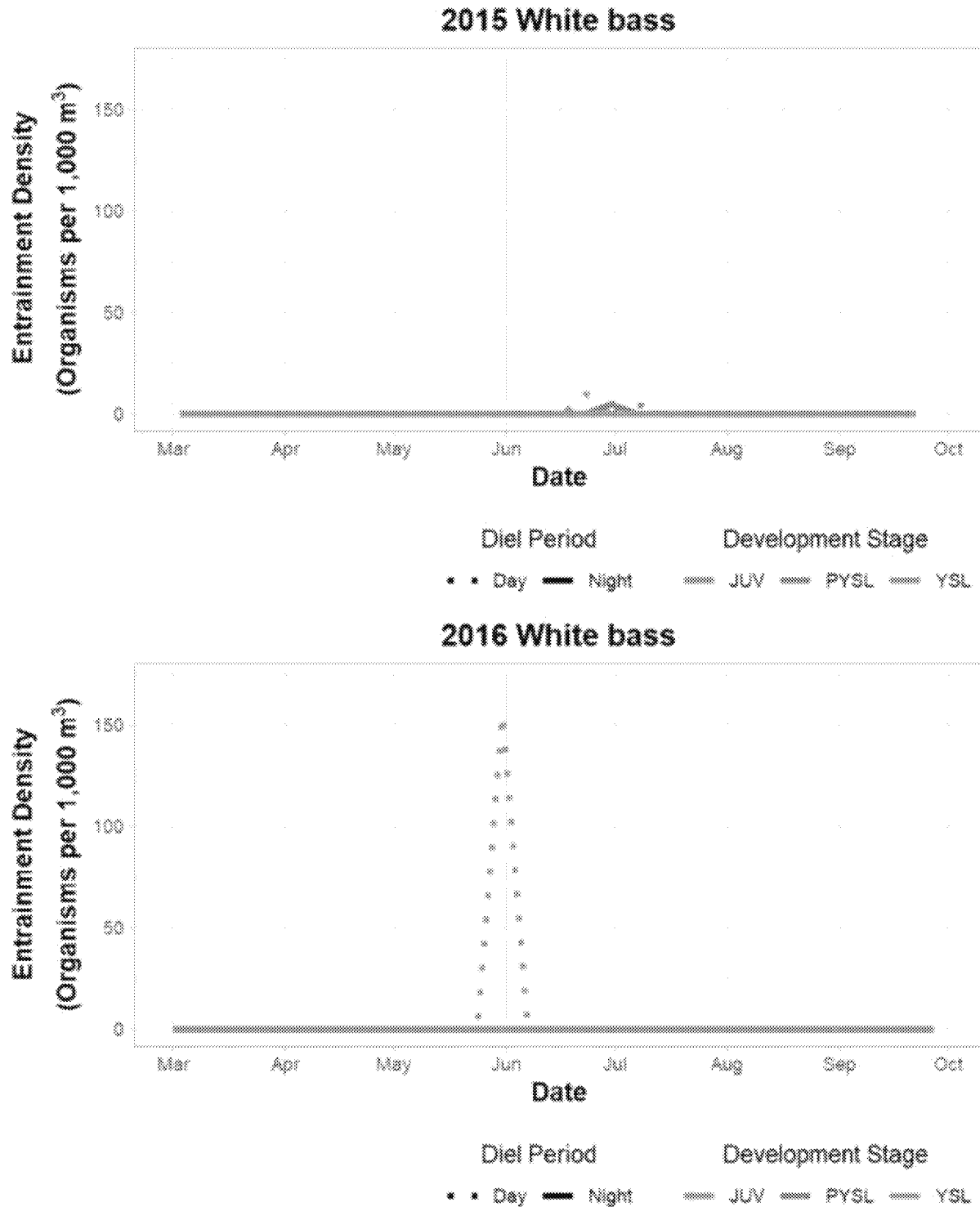


Figure 9 C-41 Mean Daytime and Nighttime Entrainment of White Bass by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

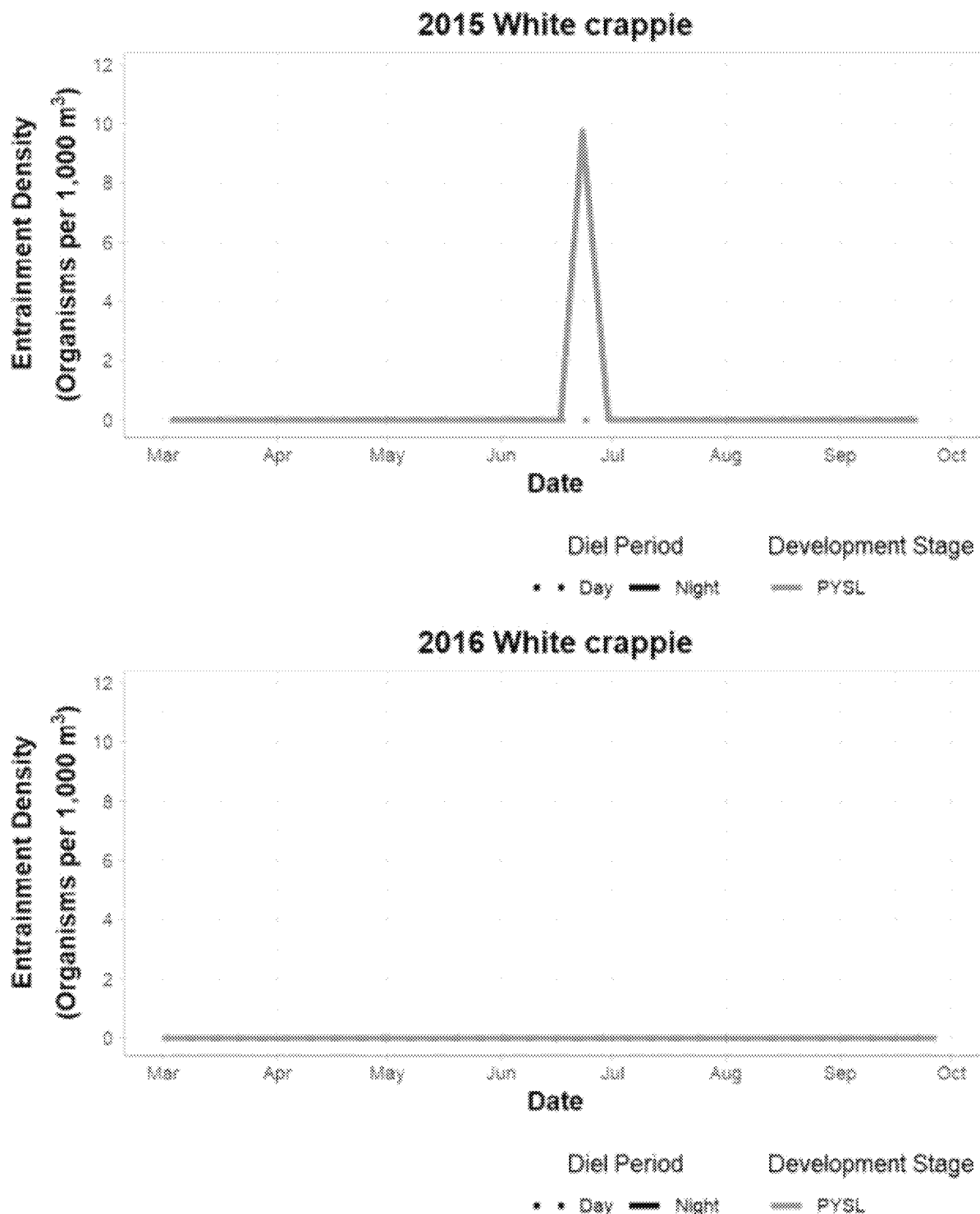


Figure 9 C-42 Mean Daytime and Nighttime Entrainment of White Crappie by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

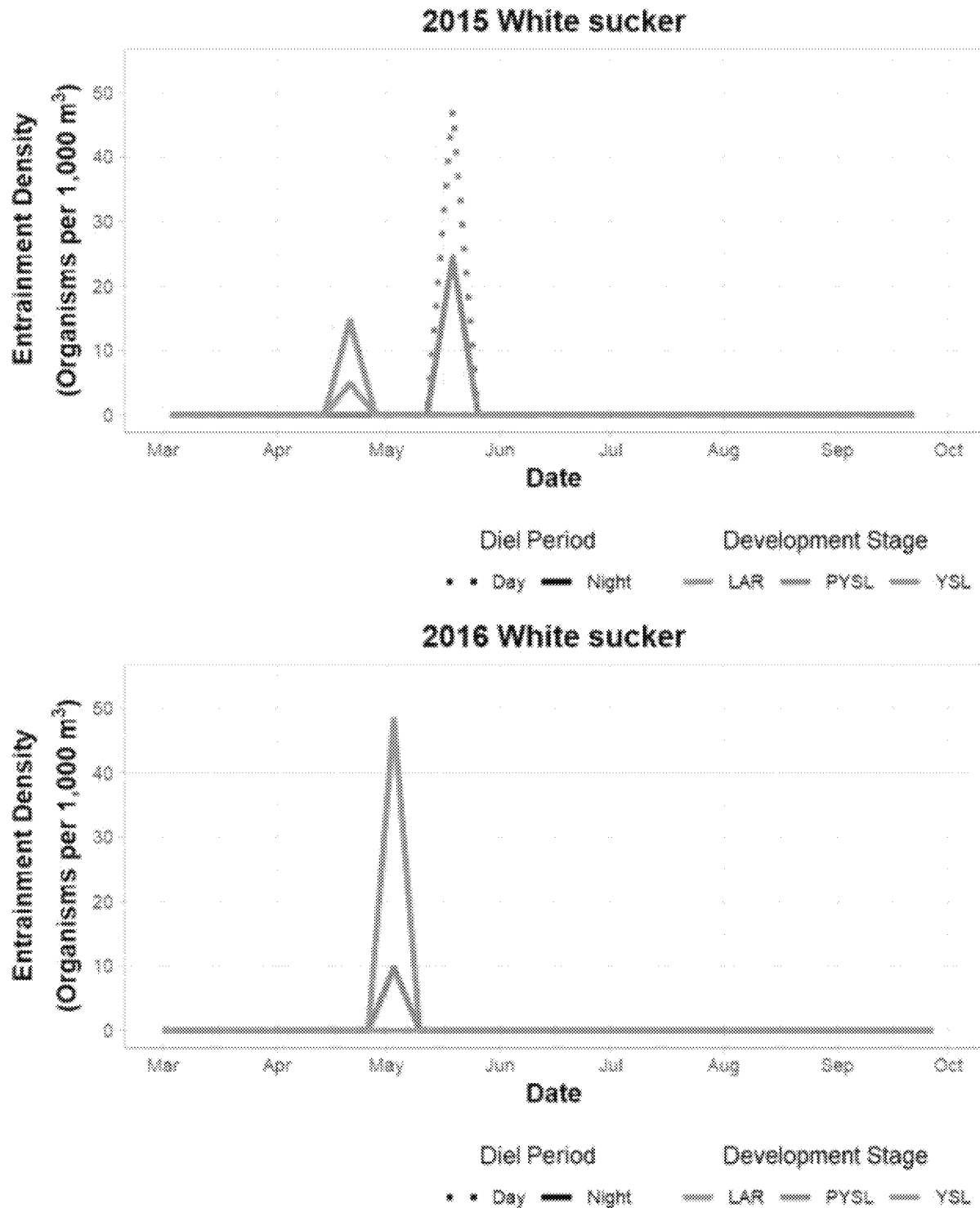


Figure 9 C-43 Mean Daytime and Nighttime Entrainment of White Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

**Appendix 9 D**  
**40 CFR 122.21(r)(9) – Entrainment Characterization Study**

**Length Histograms of All Taxa and Development Stages Entrained at  
Labadie Energy Center, 2015 and 2016**

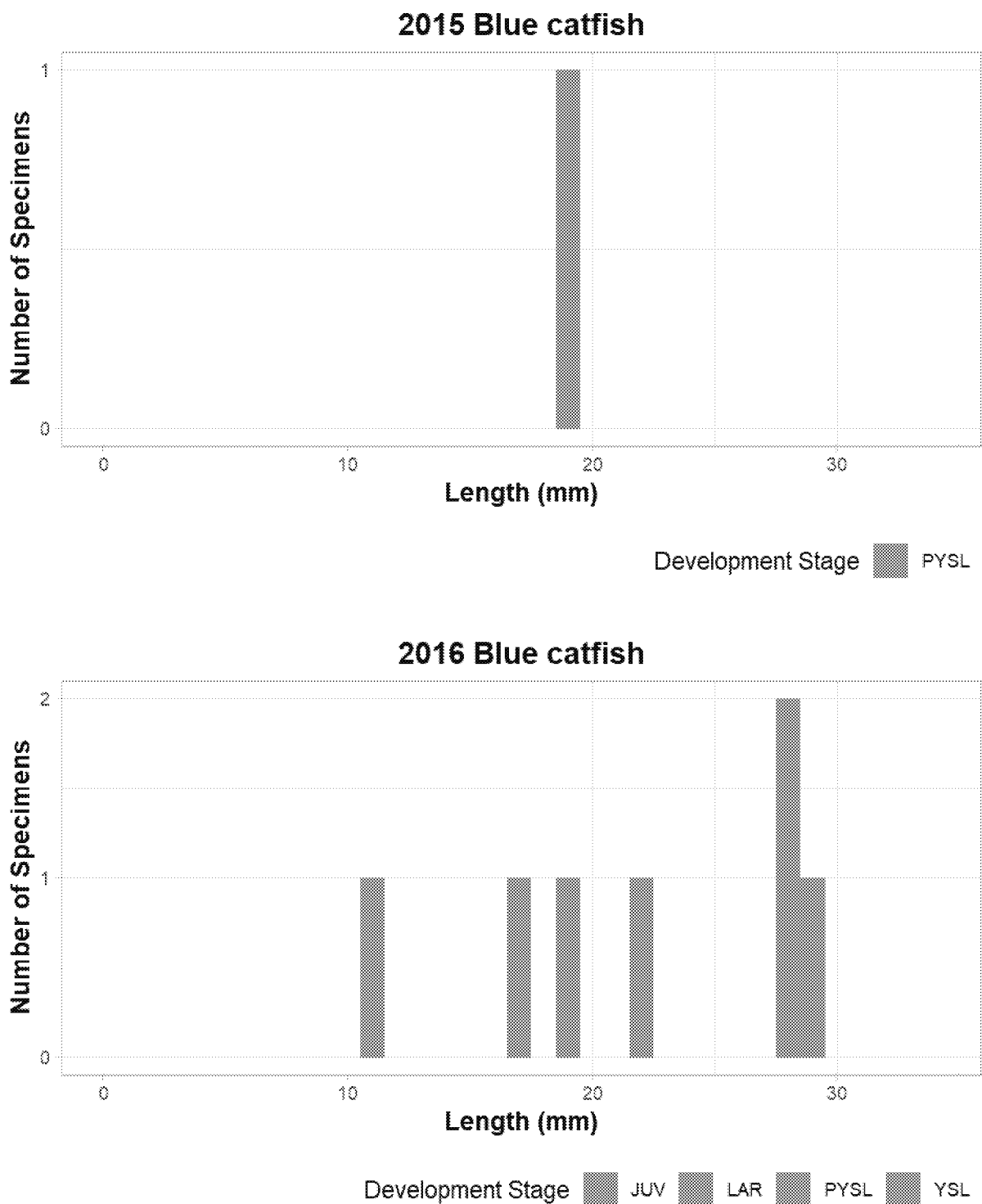
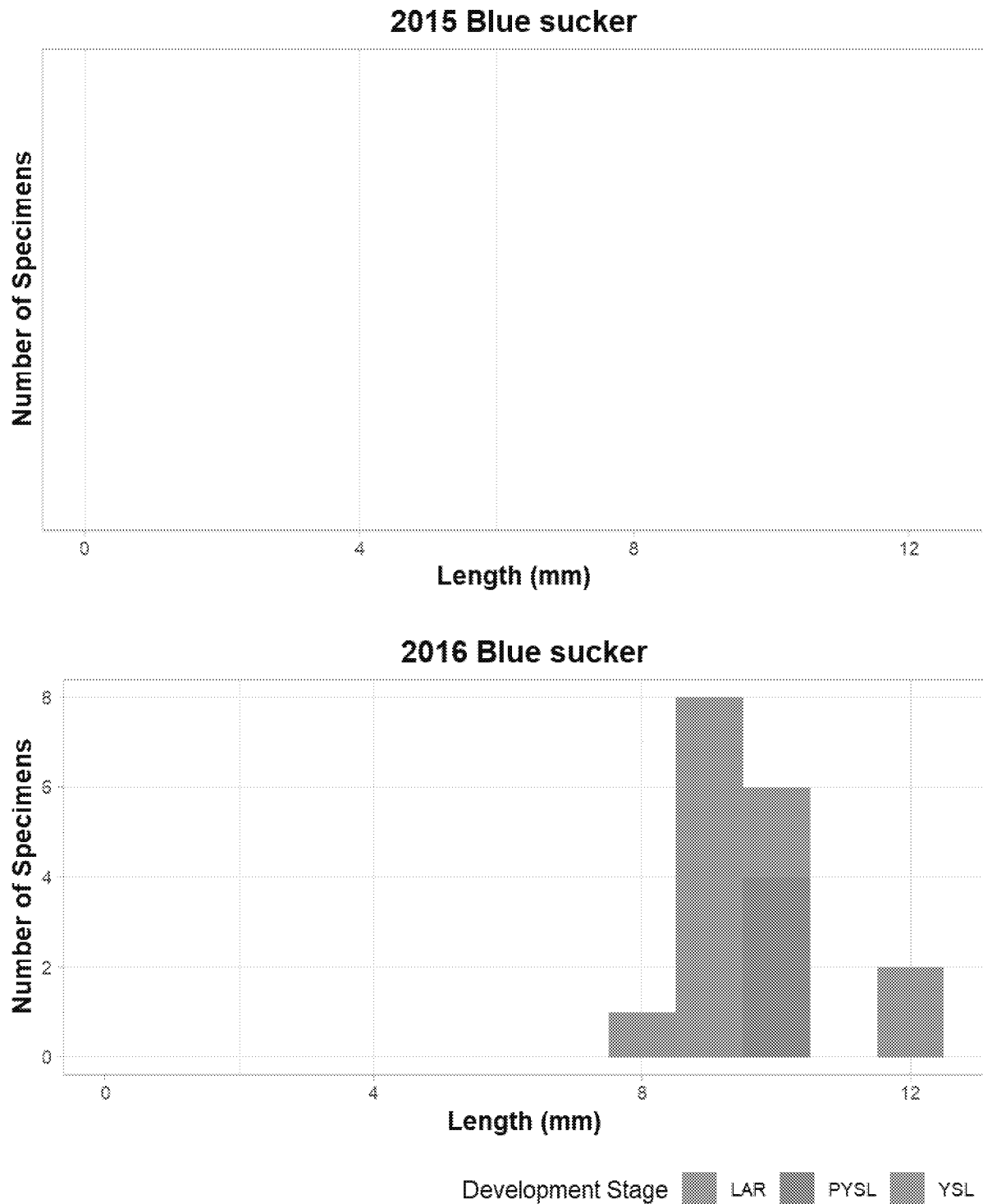


Figure 9 D-1 Length Histogram of Entrained Blue Catfish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.





**Figure 9 D-2 Length Histogram of Entrained Blue Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

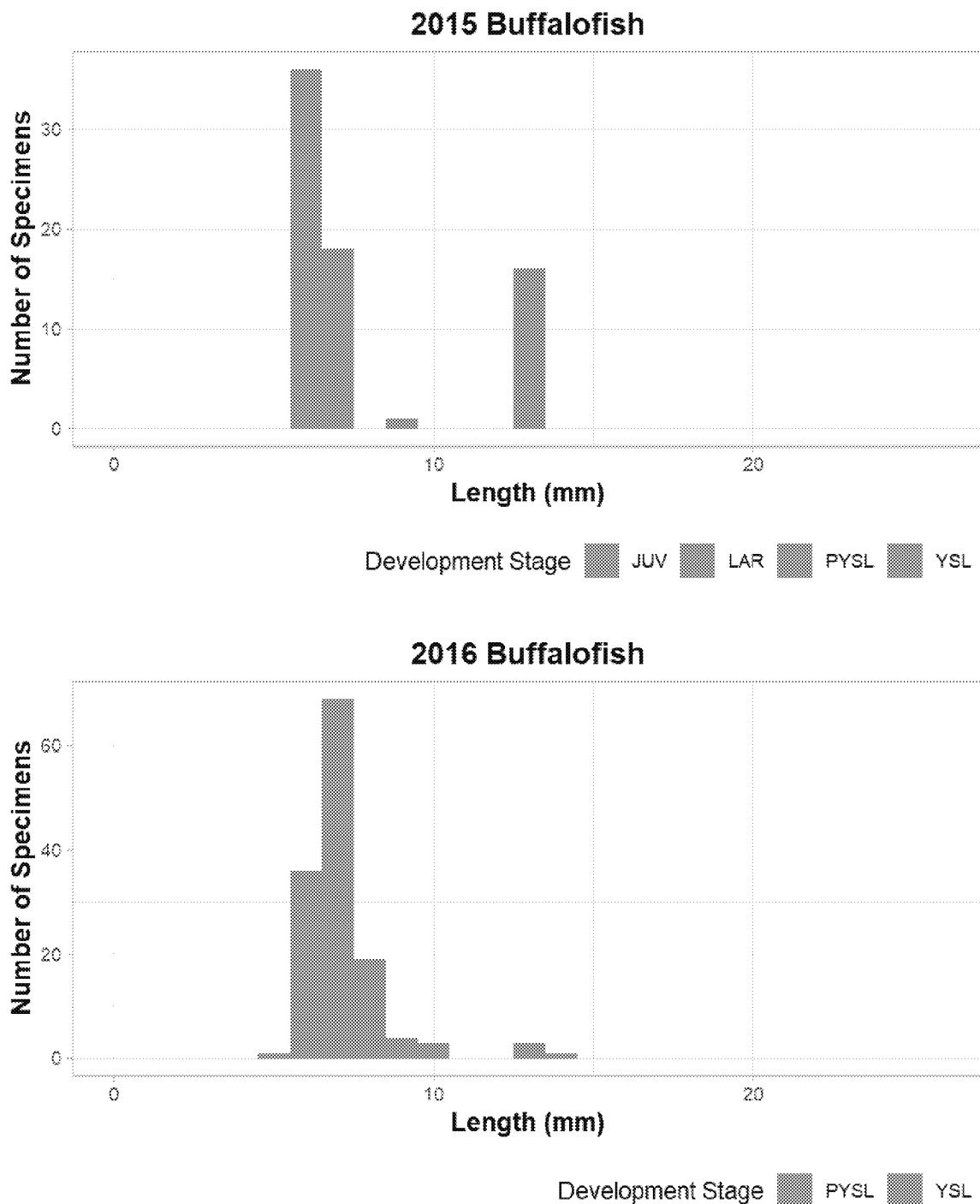


Figure 9 D-3 Length Histogram of Entrained Buffalos (*Ictiobus* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

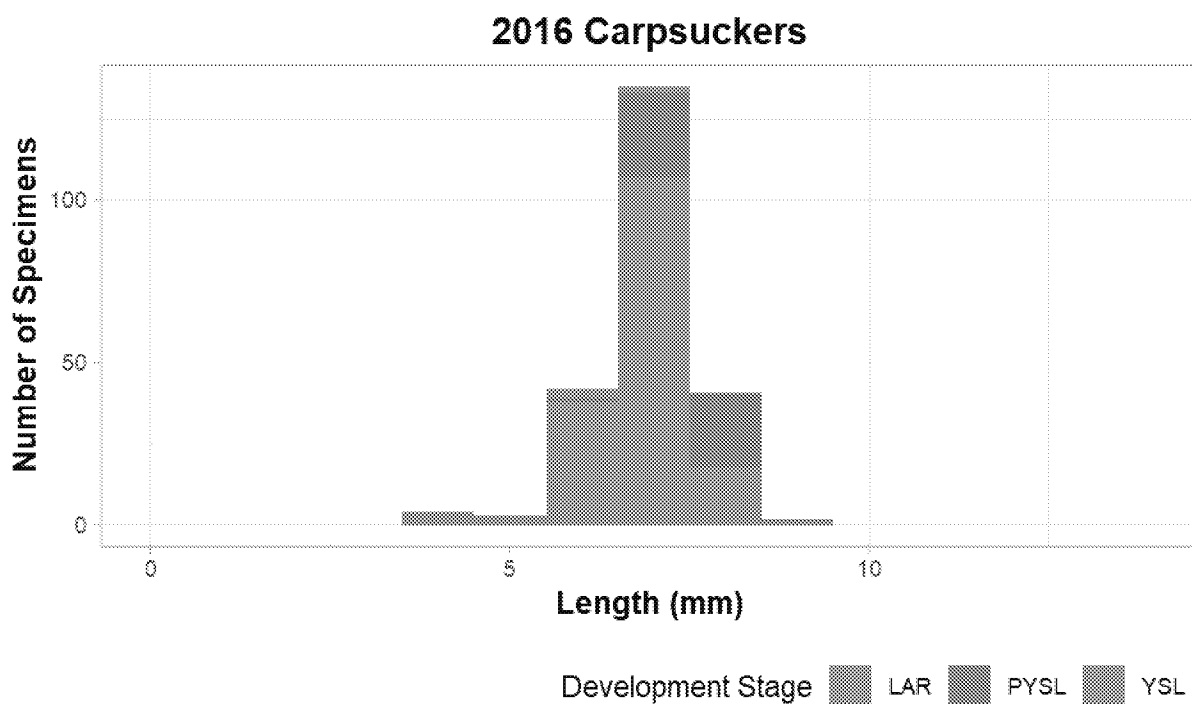
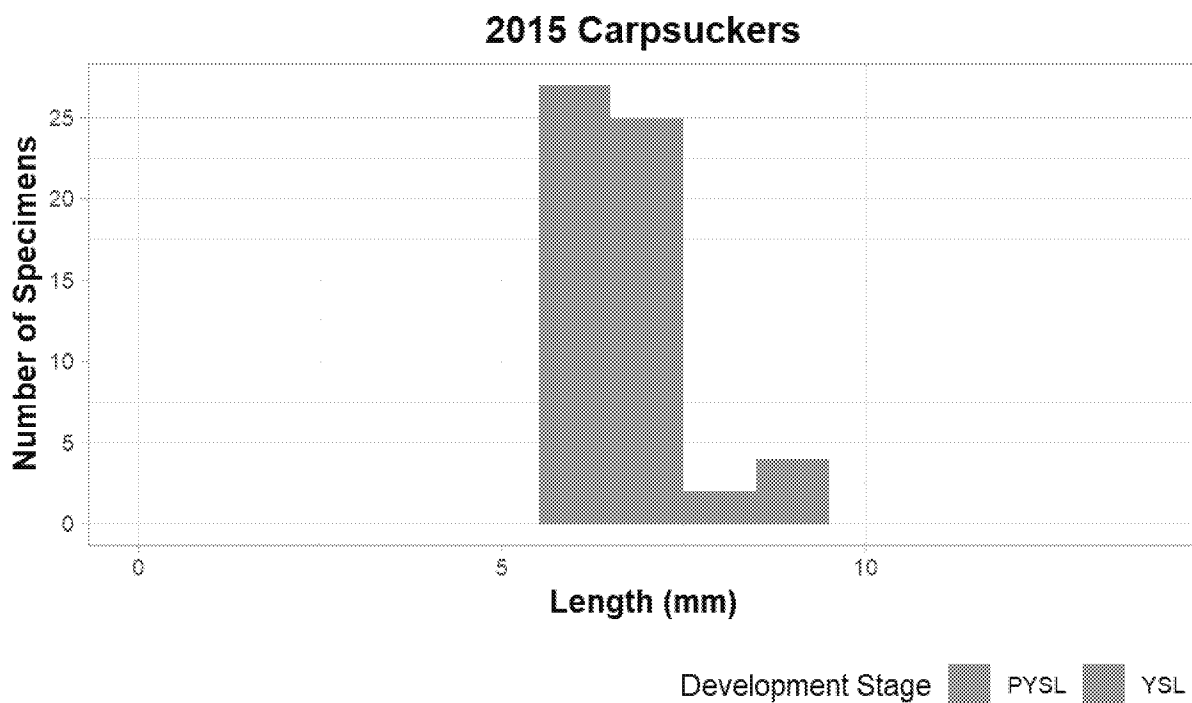


Figure 9 D-4 Length Histogram of Entrained Carpsuckers (*Carpionidae* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

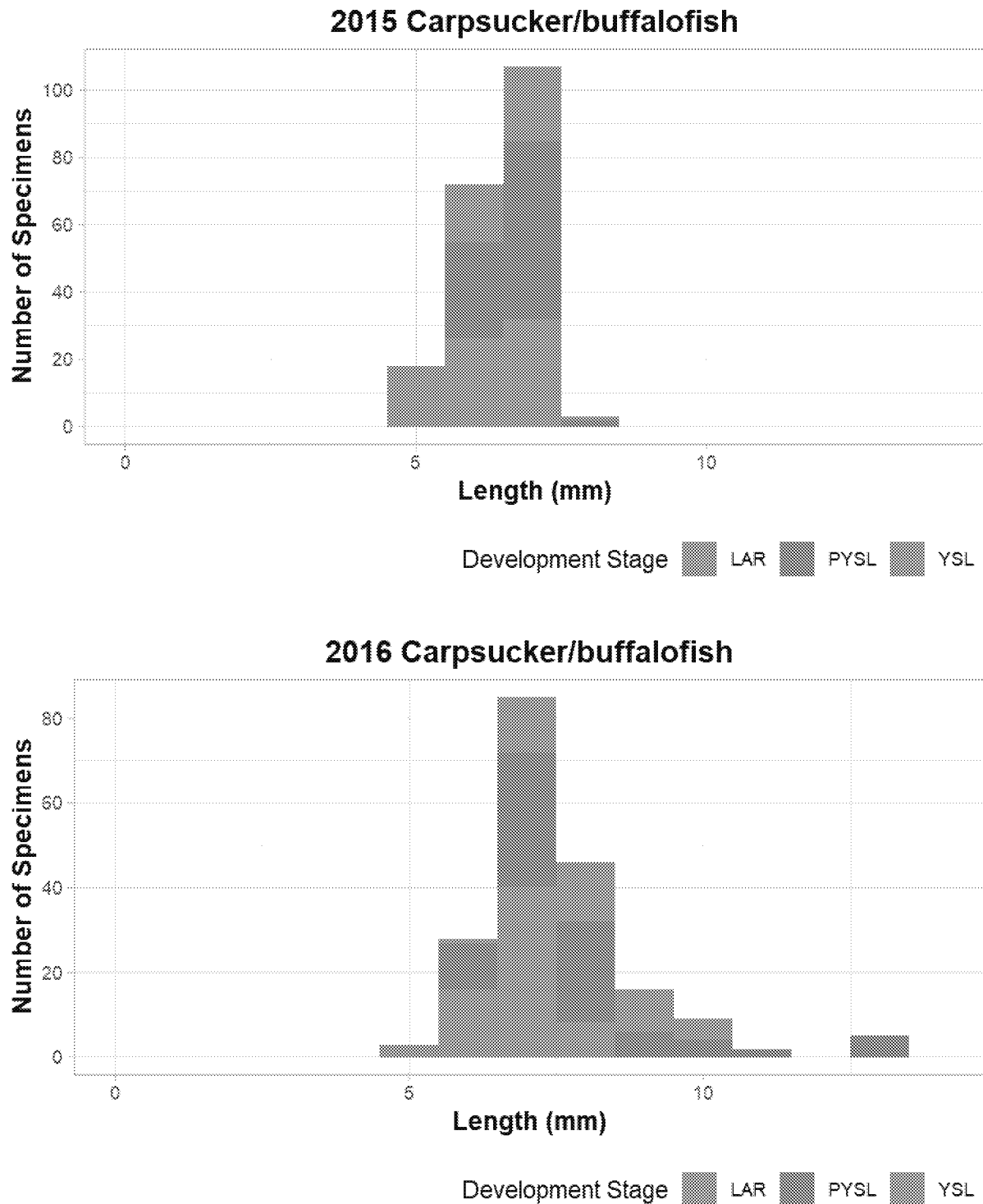


Figure 9 D-5 Length Histogram of Entrained Carpsuckers and Buffalos (Subfamily Ictiobinae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

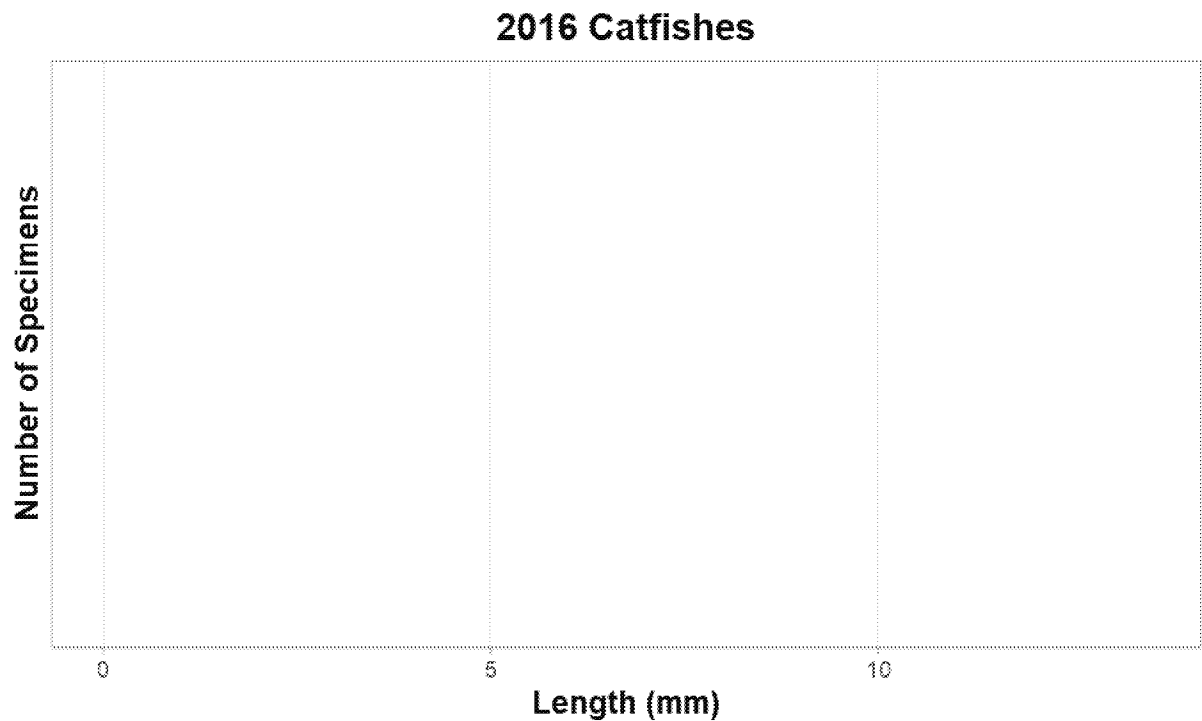
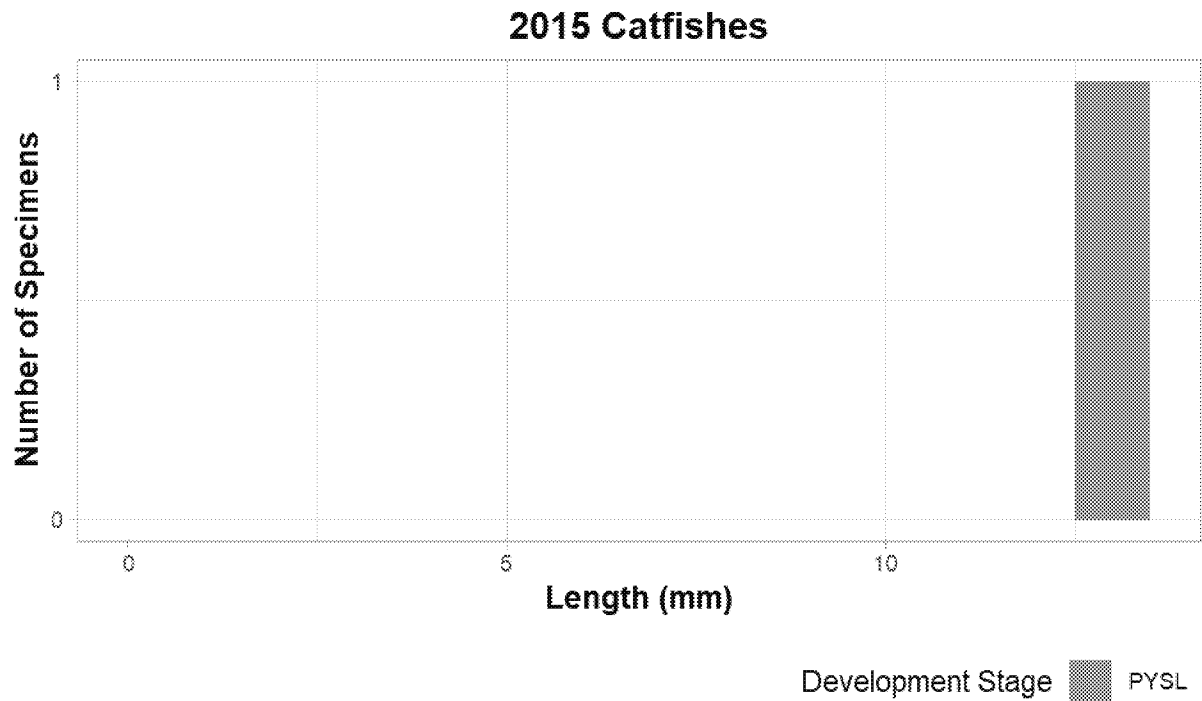
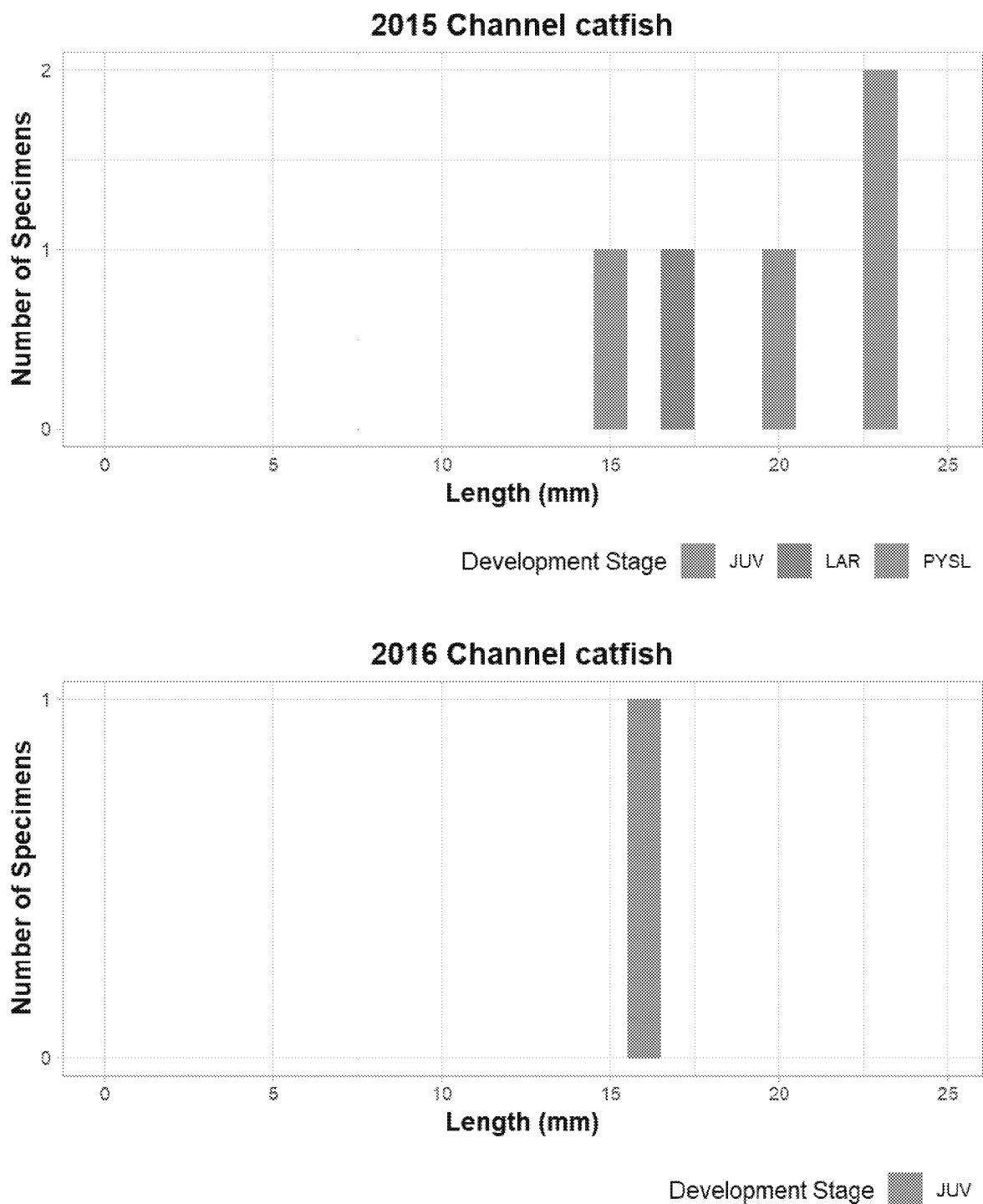


Figure 9 D-6 Length Histogram of Entrained North American Catfishes (Family Ictaluridae) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 D-7 Length Histogram of Entrained Channel Catfish by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

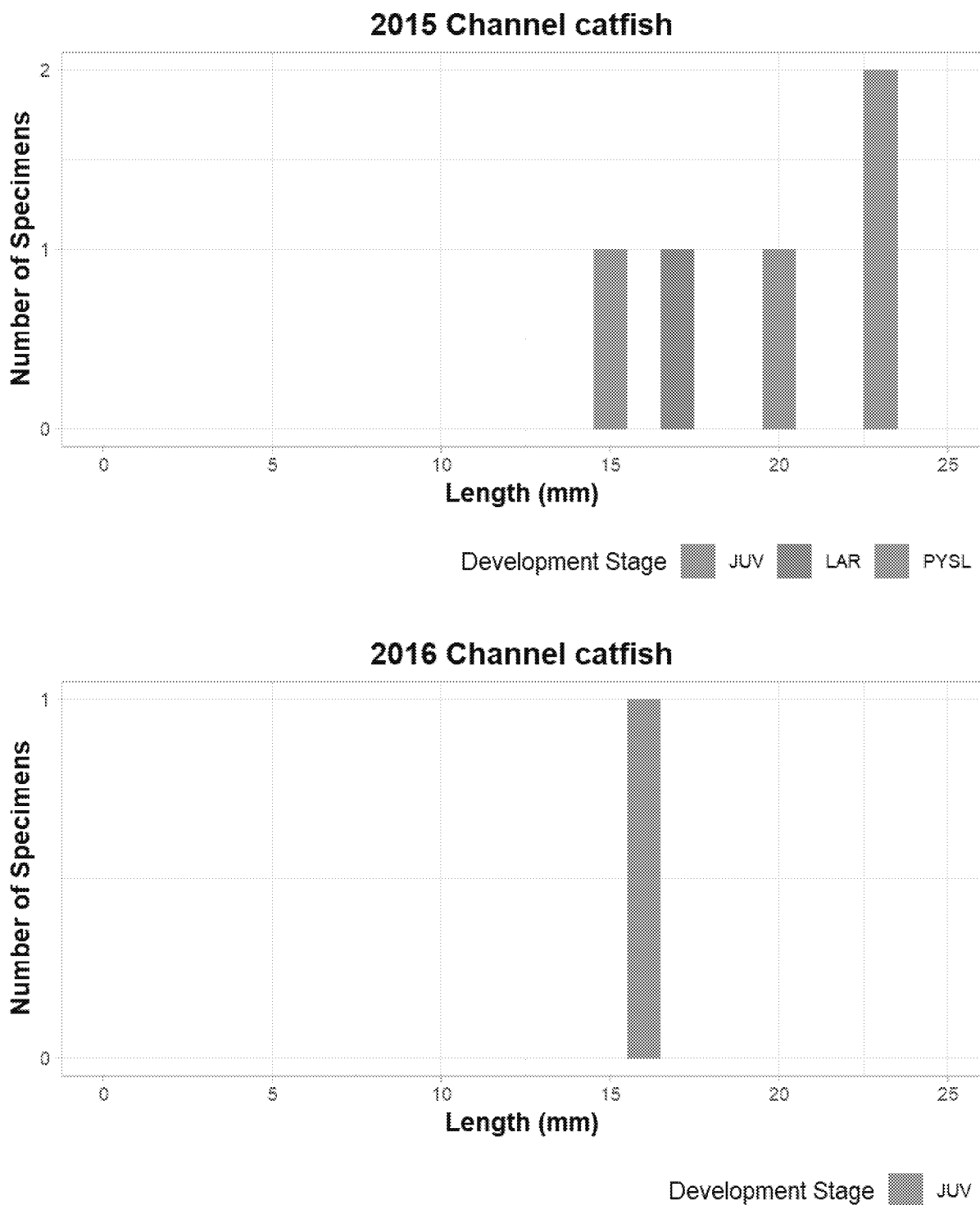
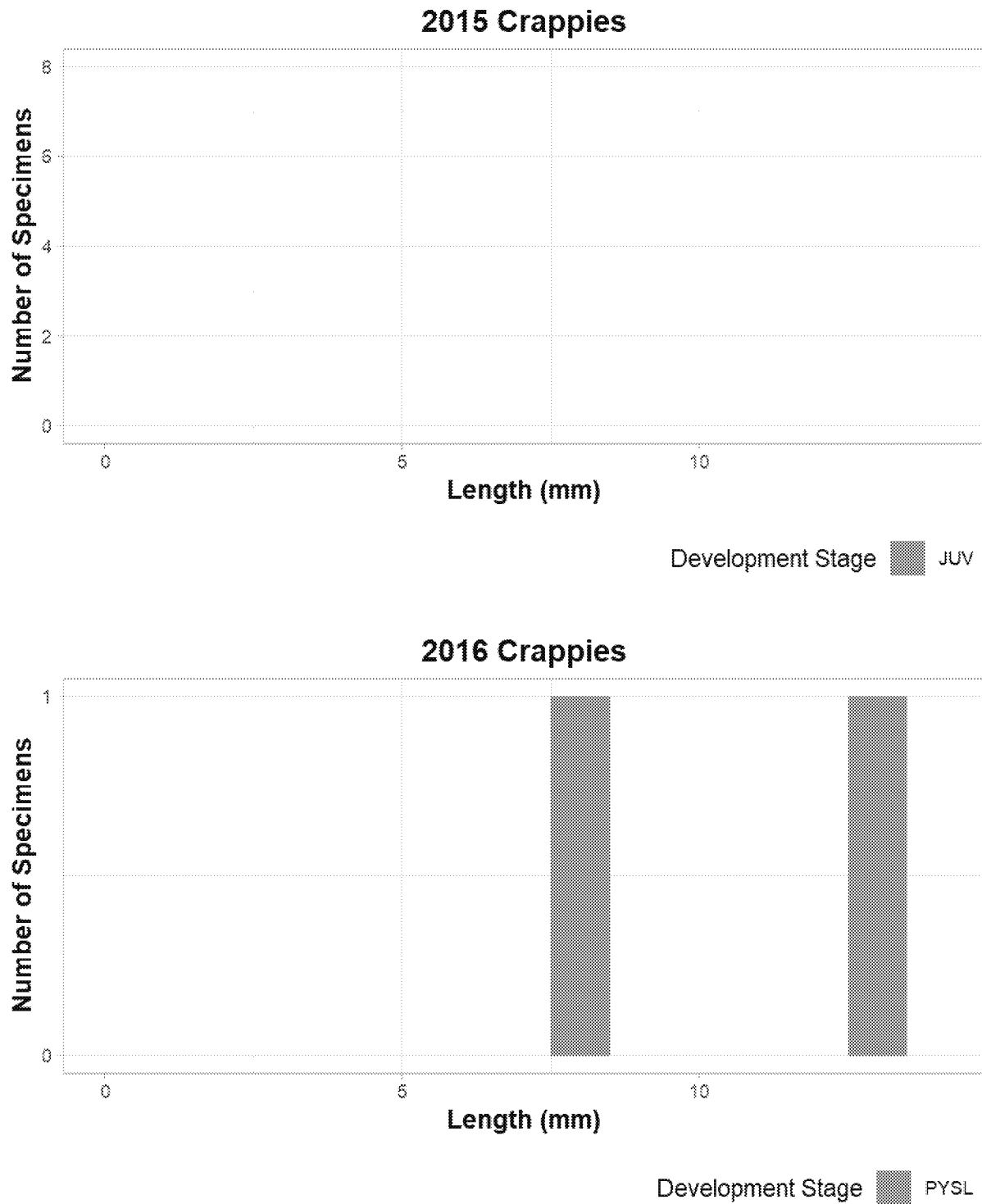


Figure 9 D-8 Length Histogram of Entrained Common Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 D-9 Length Histogram of Entrained Crappies (*Pomoxis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



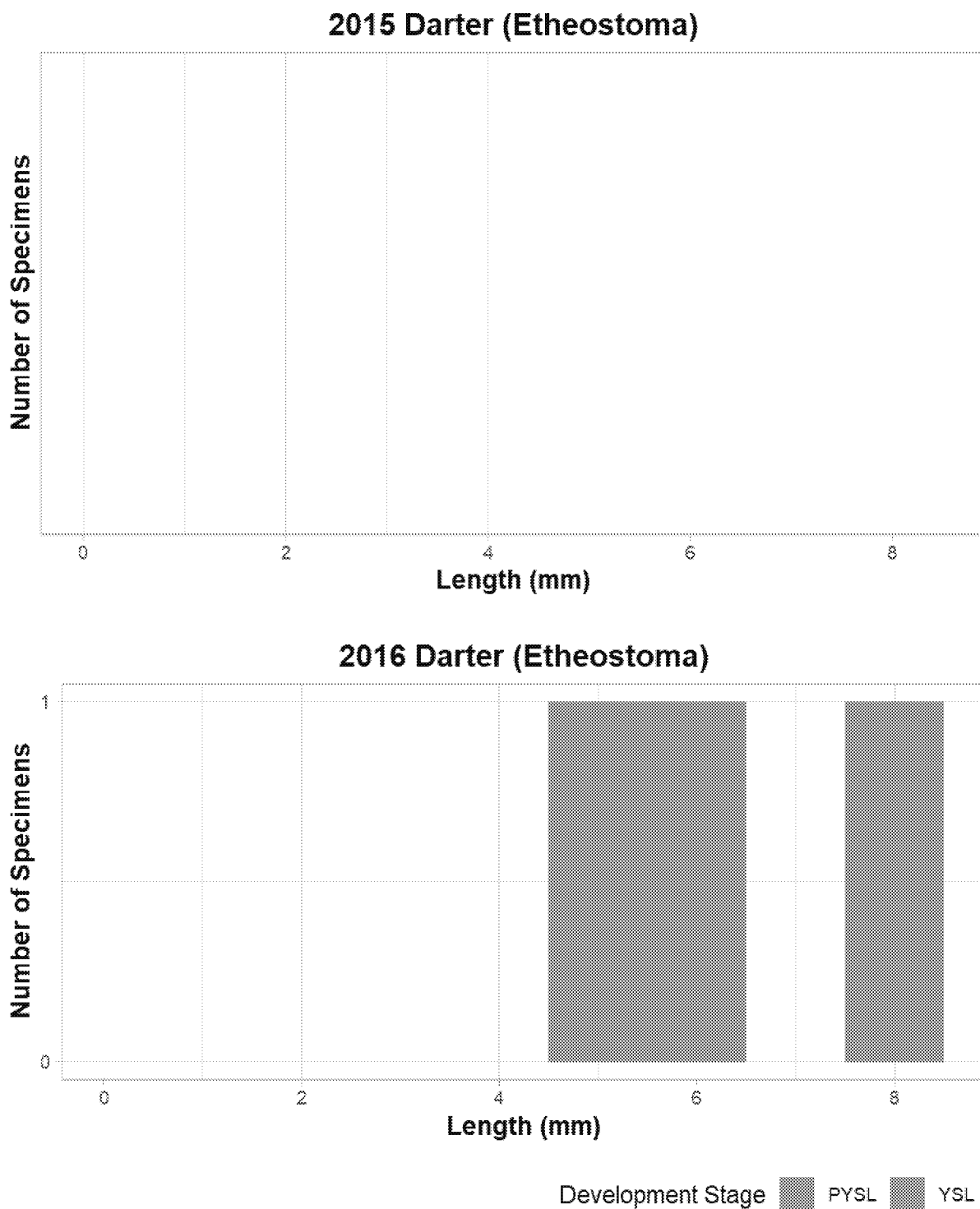


Figure 9 D-10 Length Histogram of Entrained Darters (*Etheostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

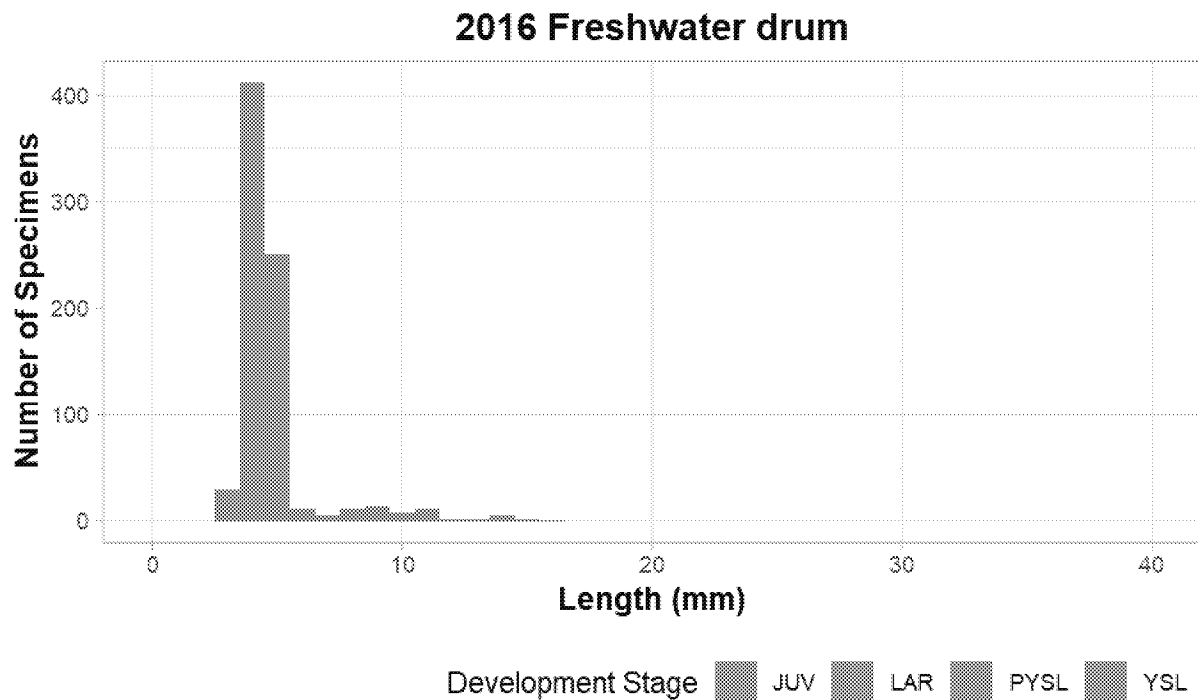
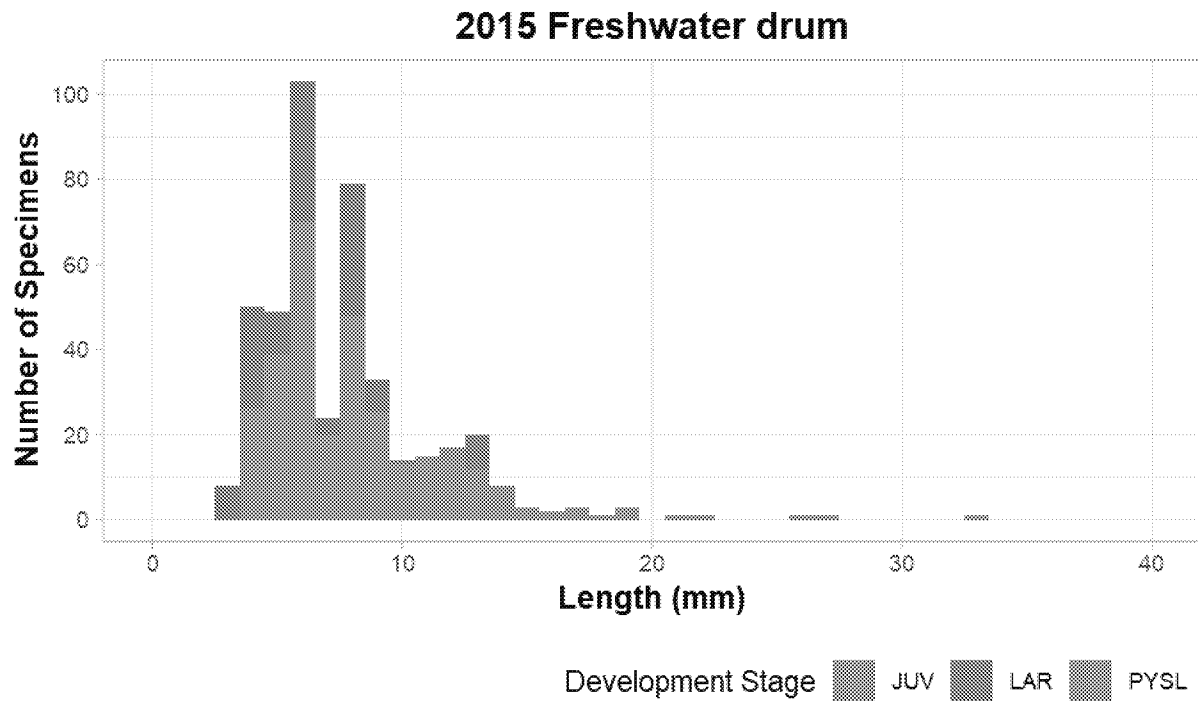
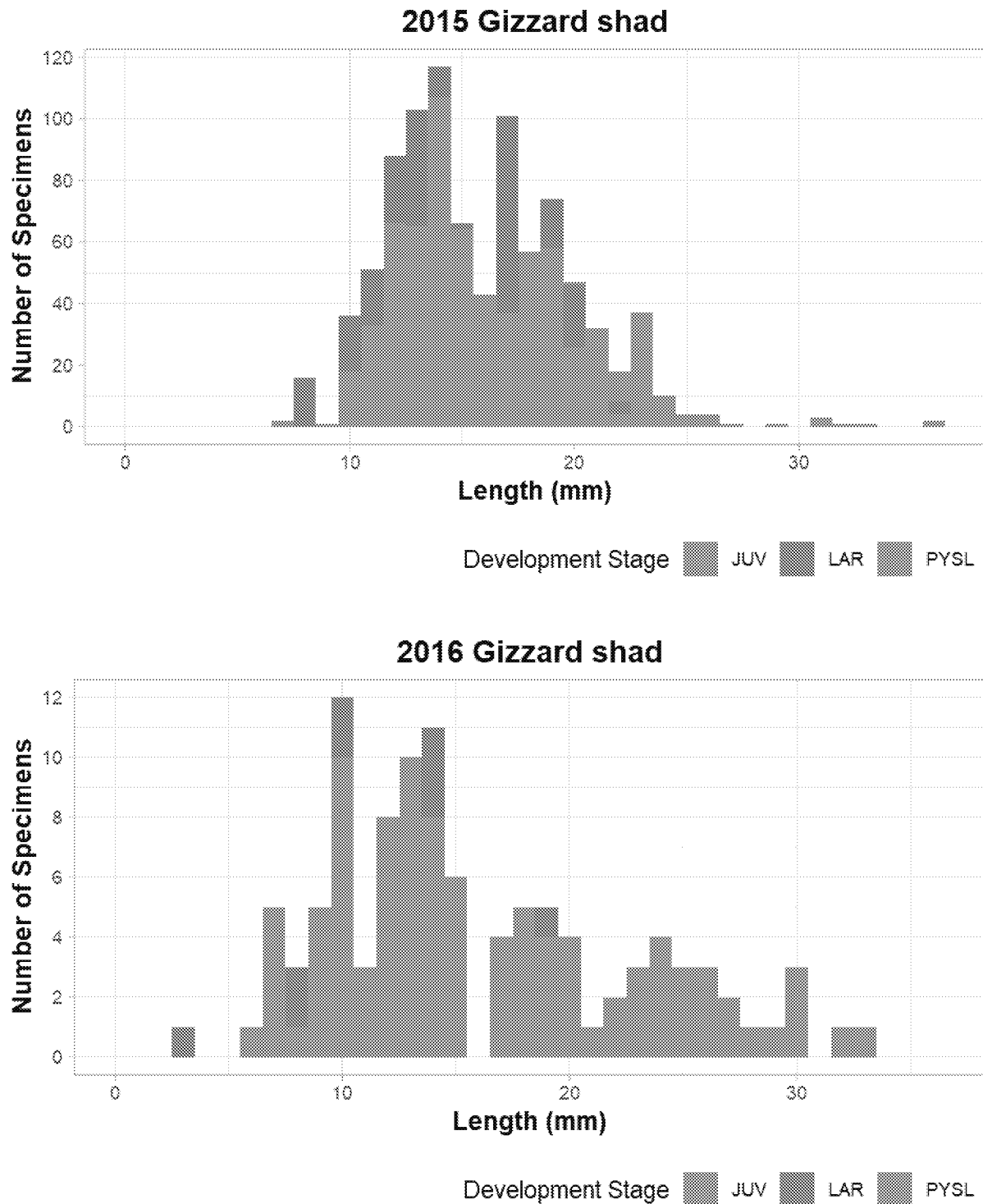


Figure 9 D-11 Length Histogram of Entrained Freshwater Drum by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 D-12 Length Histogram of Entrained Gizzard Shad by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

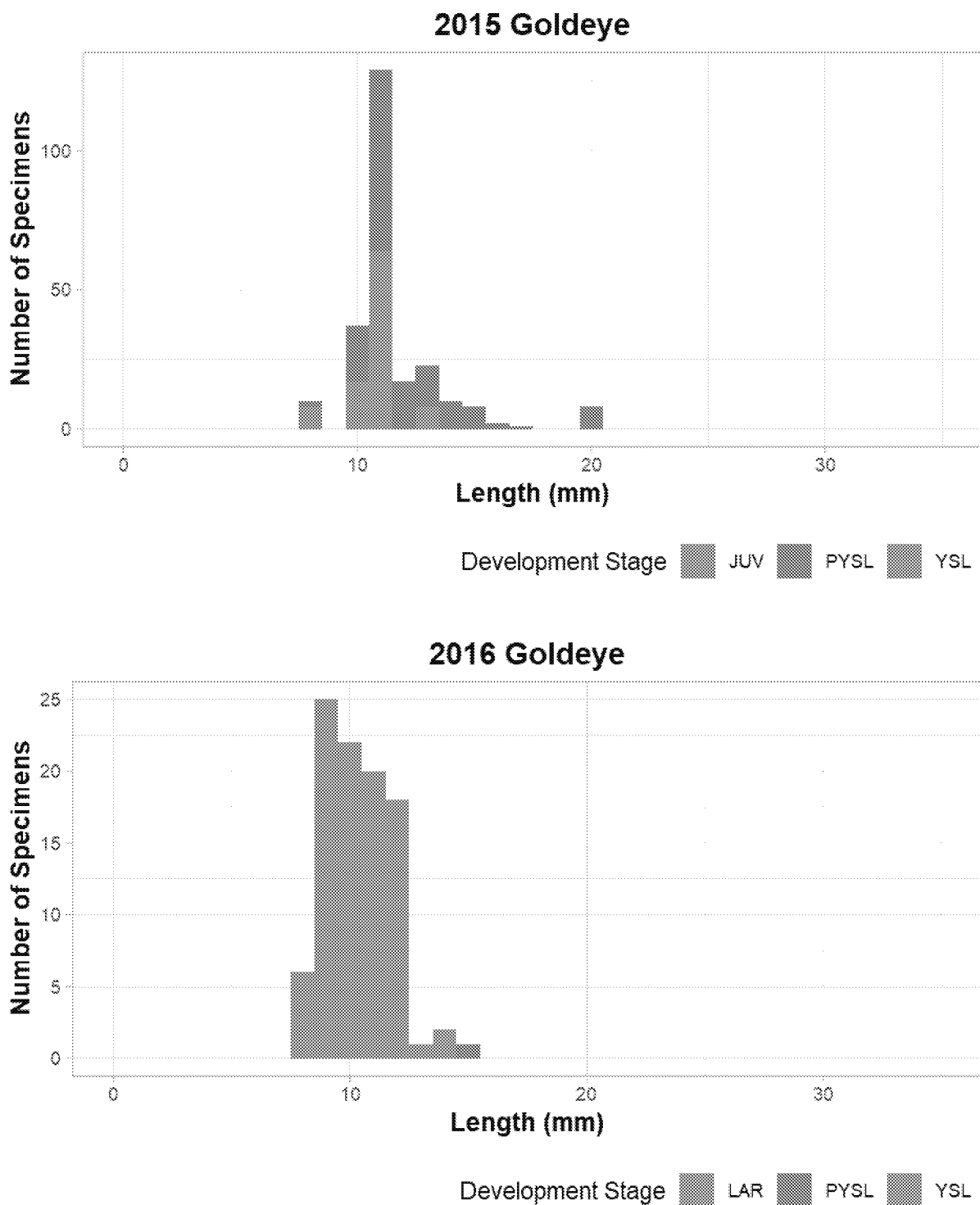


Figure 9 D-13 Length Histogram of Entrained Goldeye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

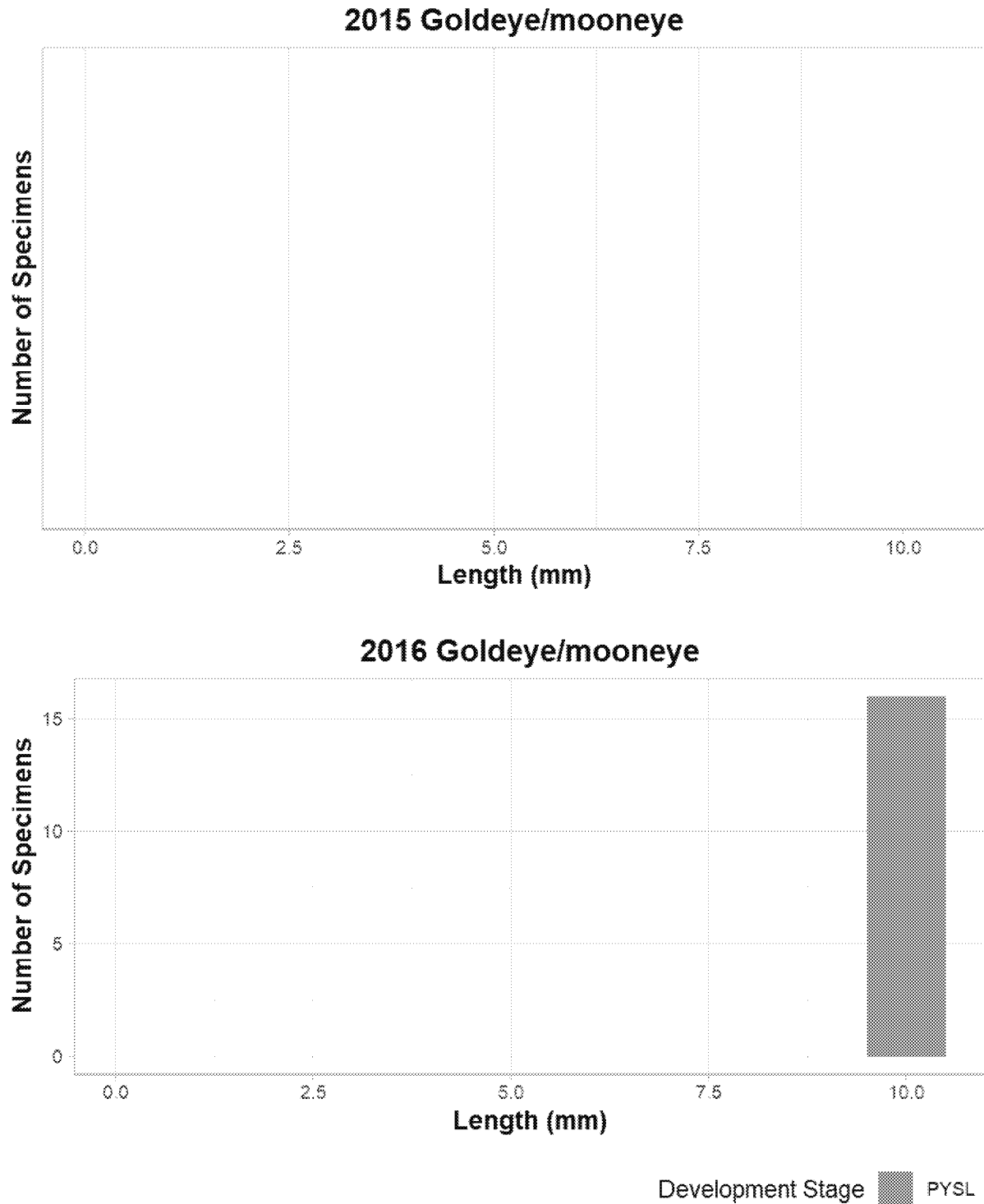
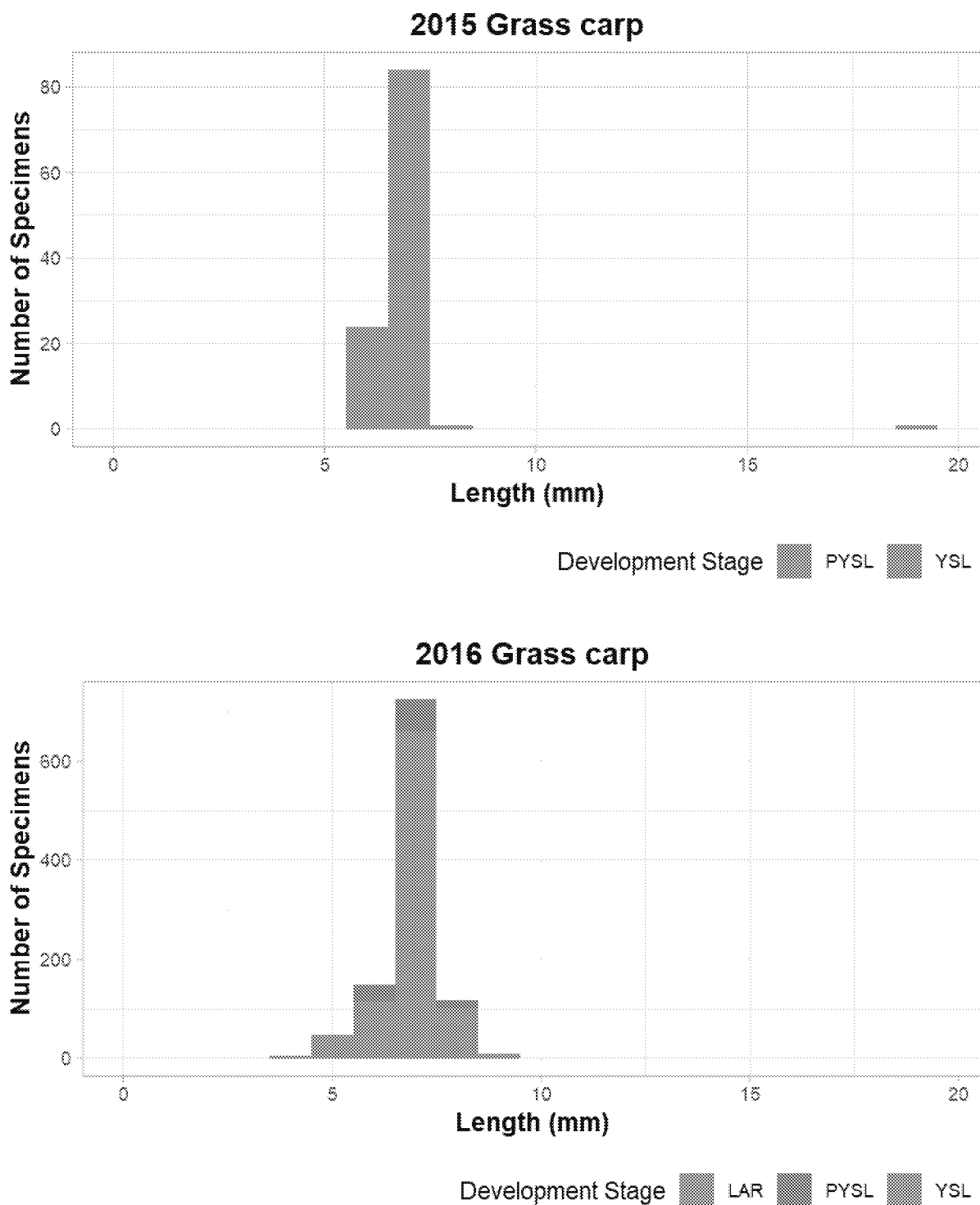


Figure 9 D-14 Length Histogram of Entrained Mooneyes (*Hiodon* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 D-15 Length Histogram of Entrained Grass Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

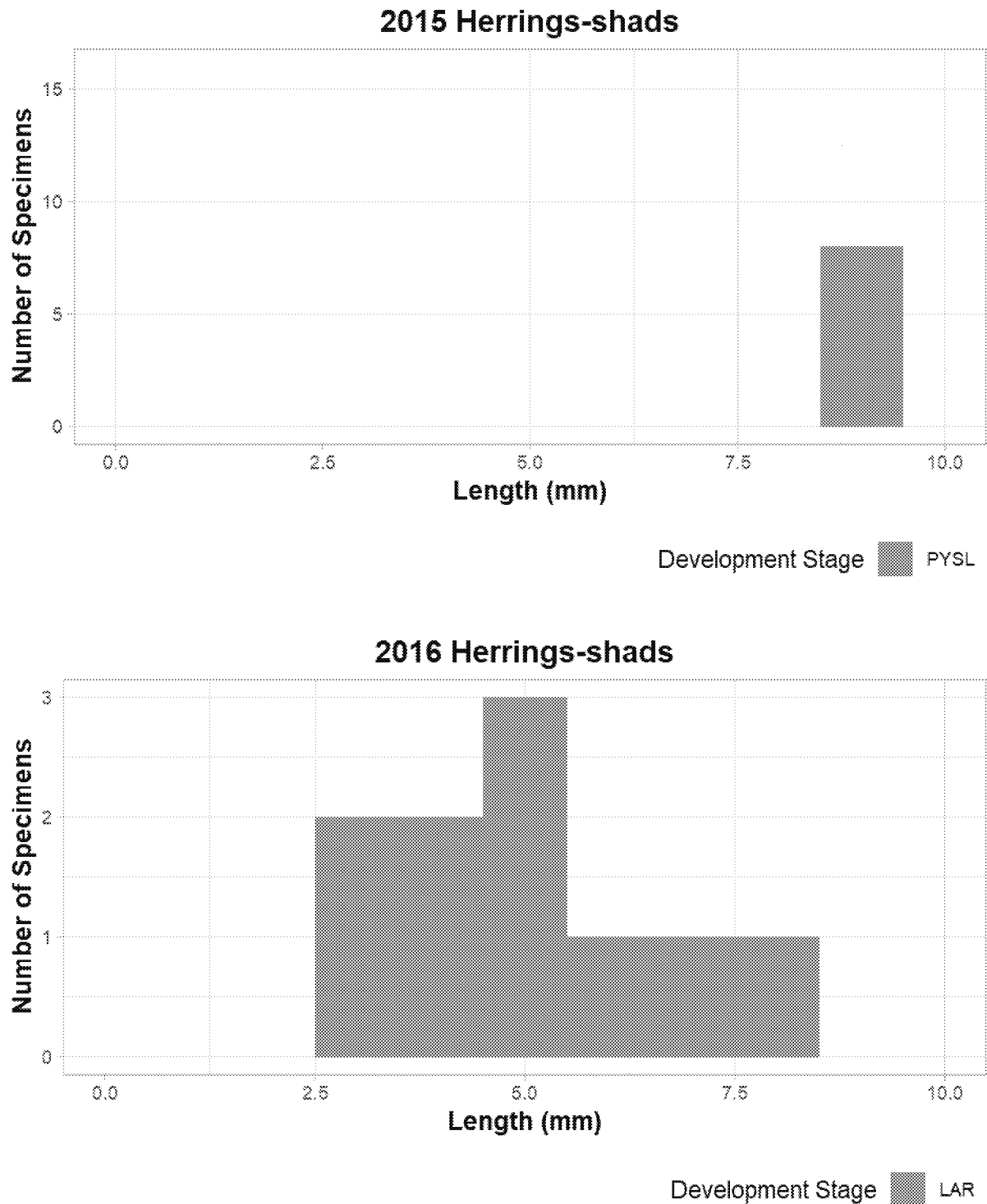
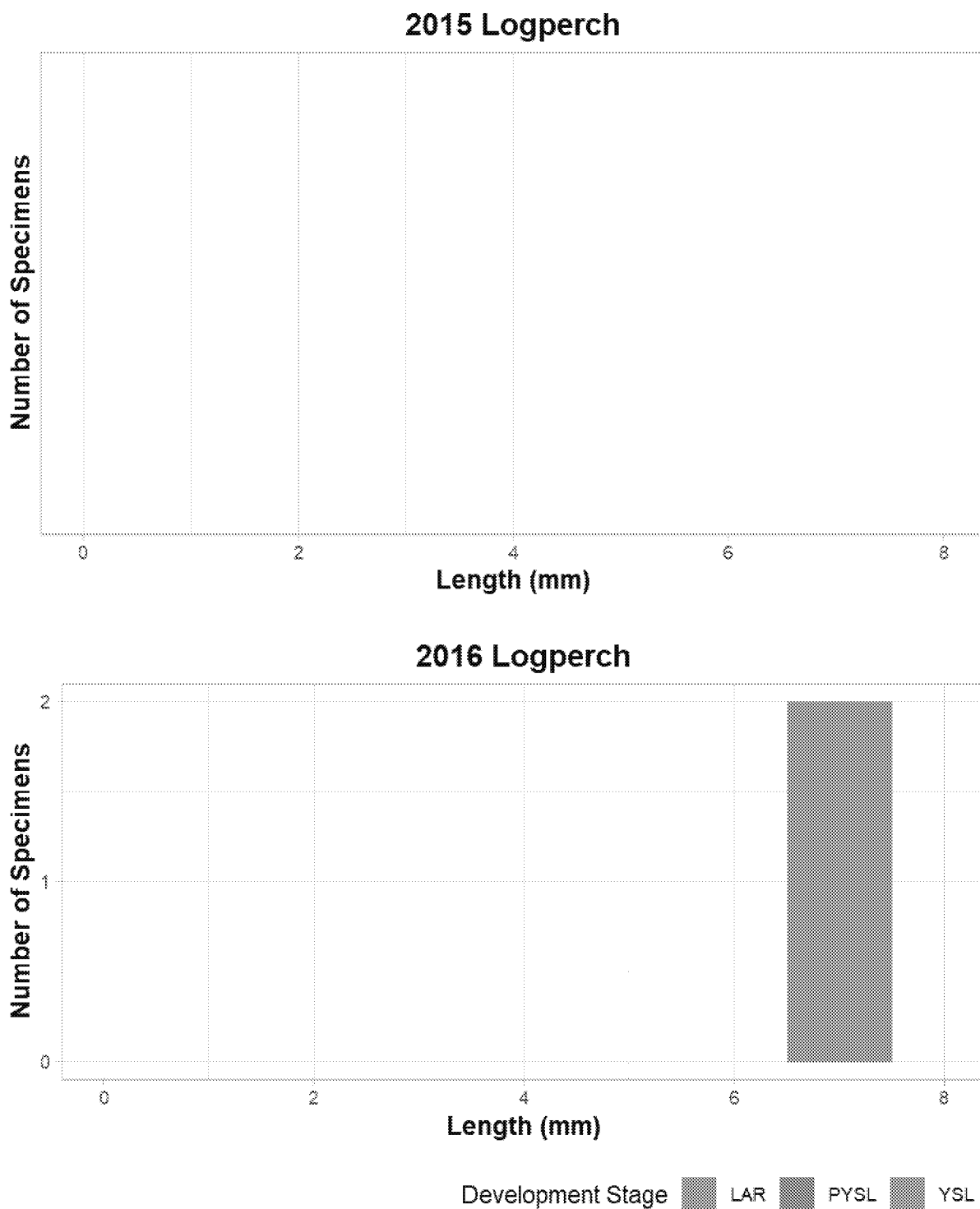
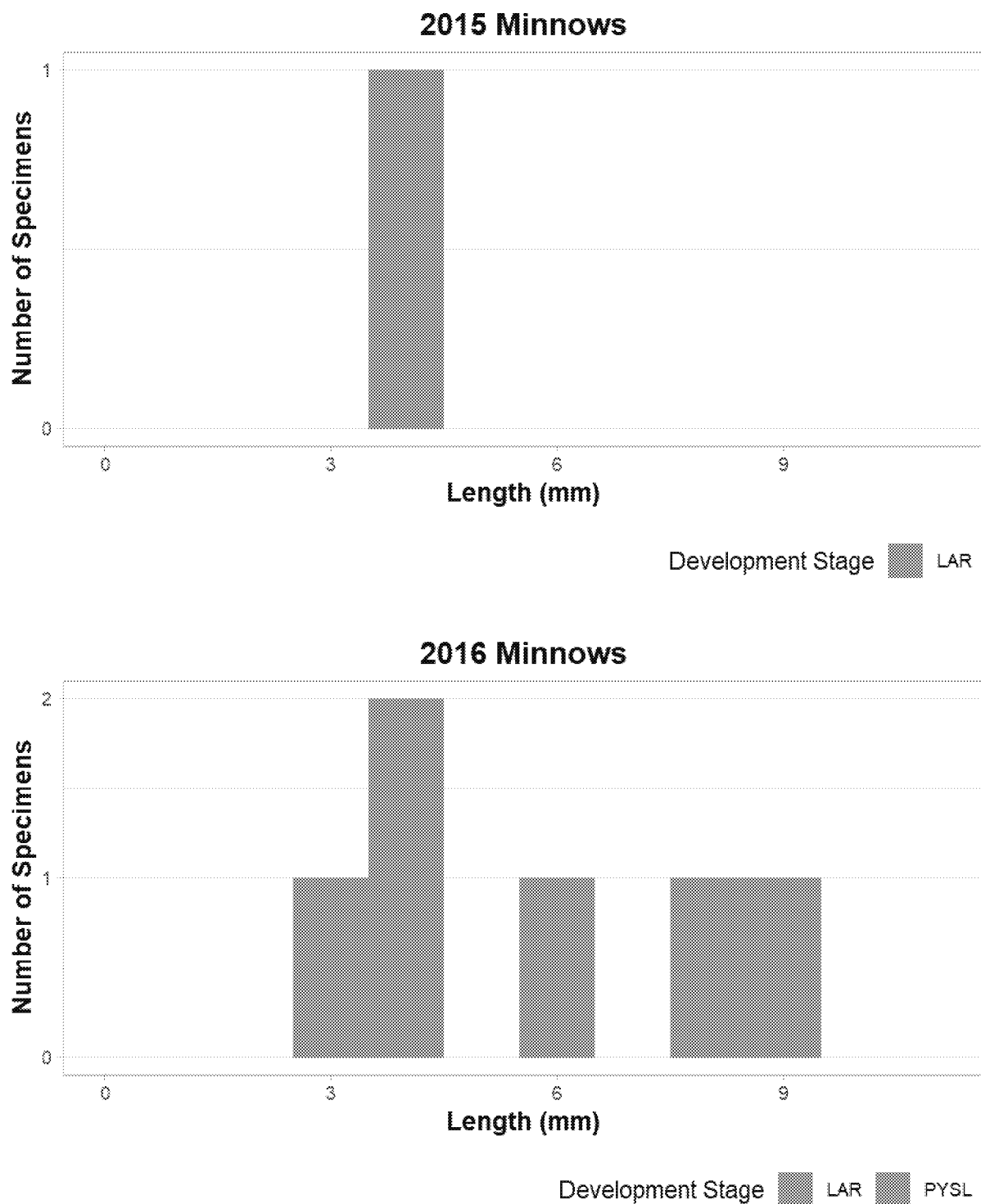


Figure 9 D-16 Length Histogram of Entrained Shads (*Dorosoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

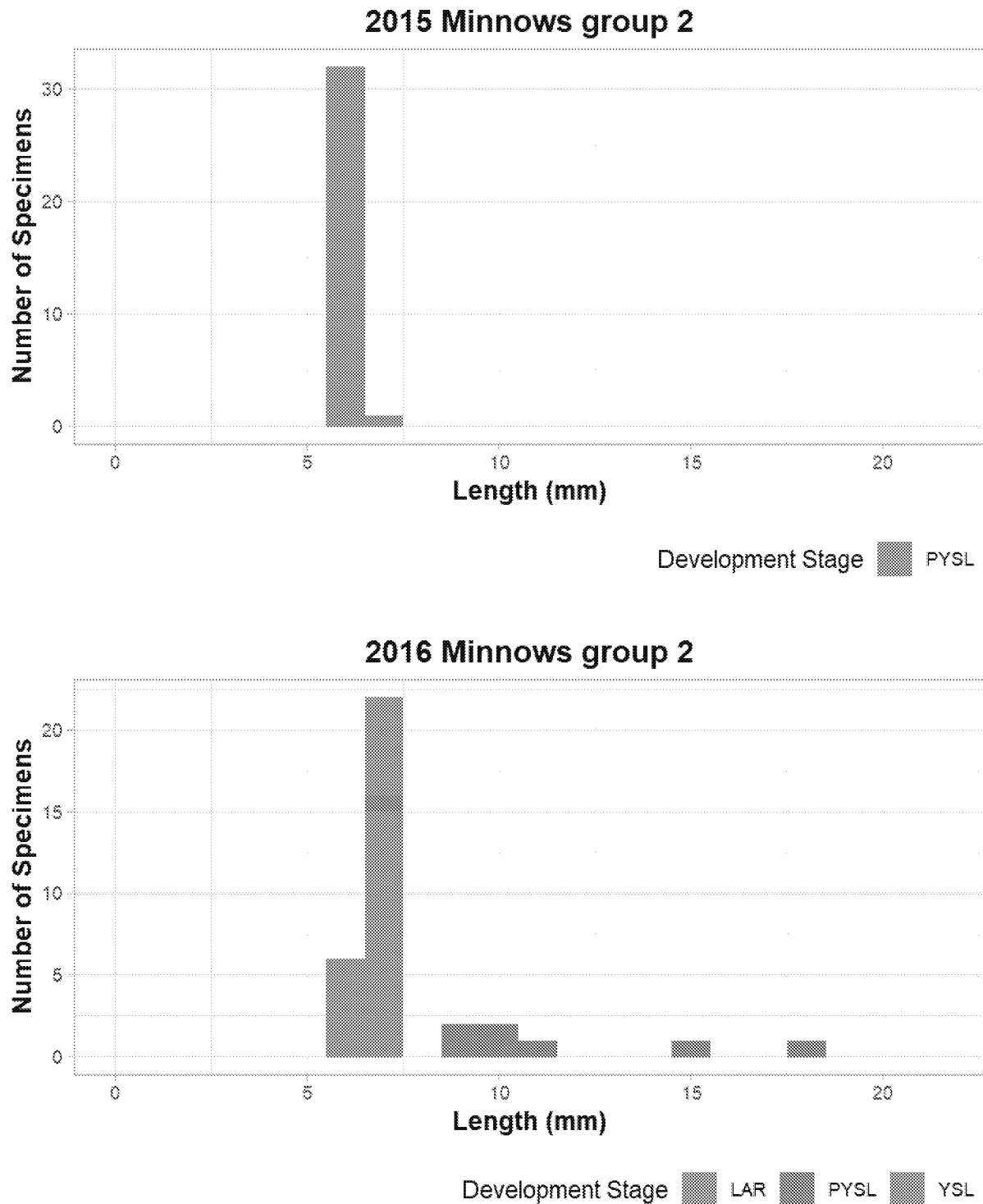


**Figure 9 D-17 Length Histogram of Entrained Logperch by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

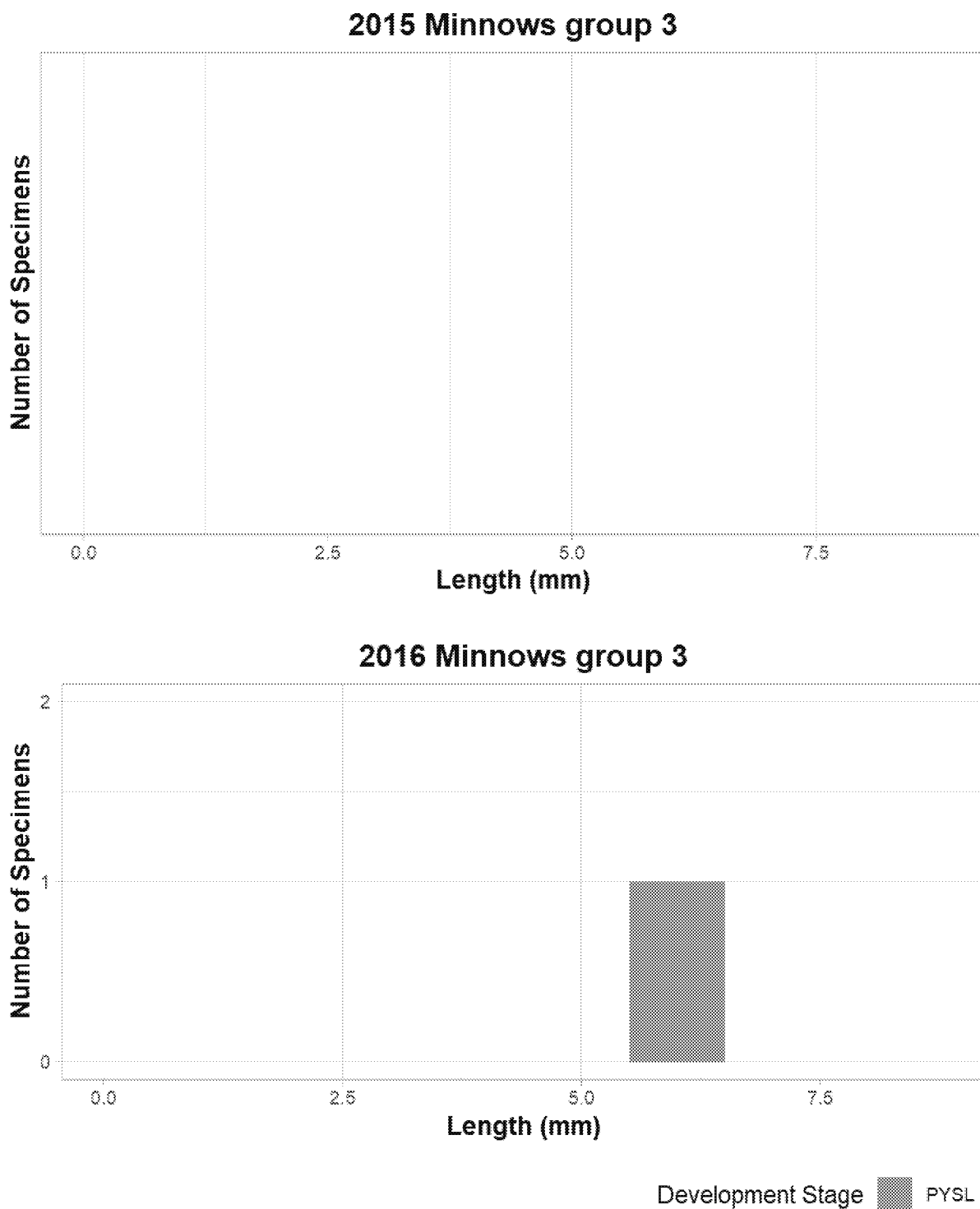




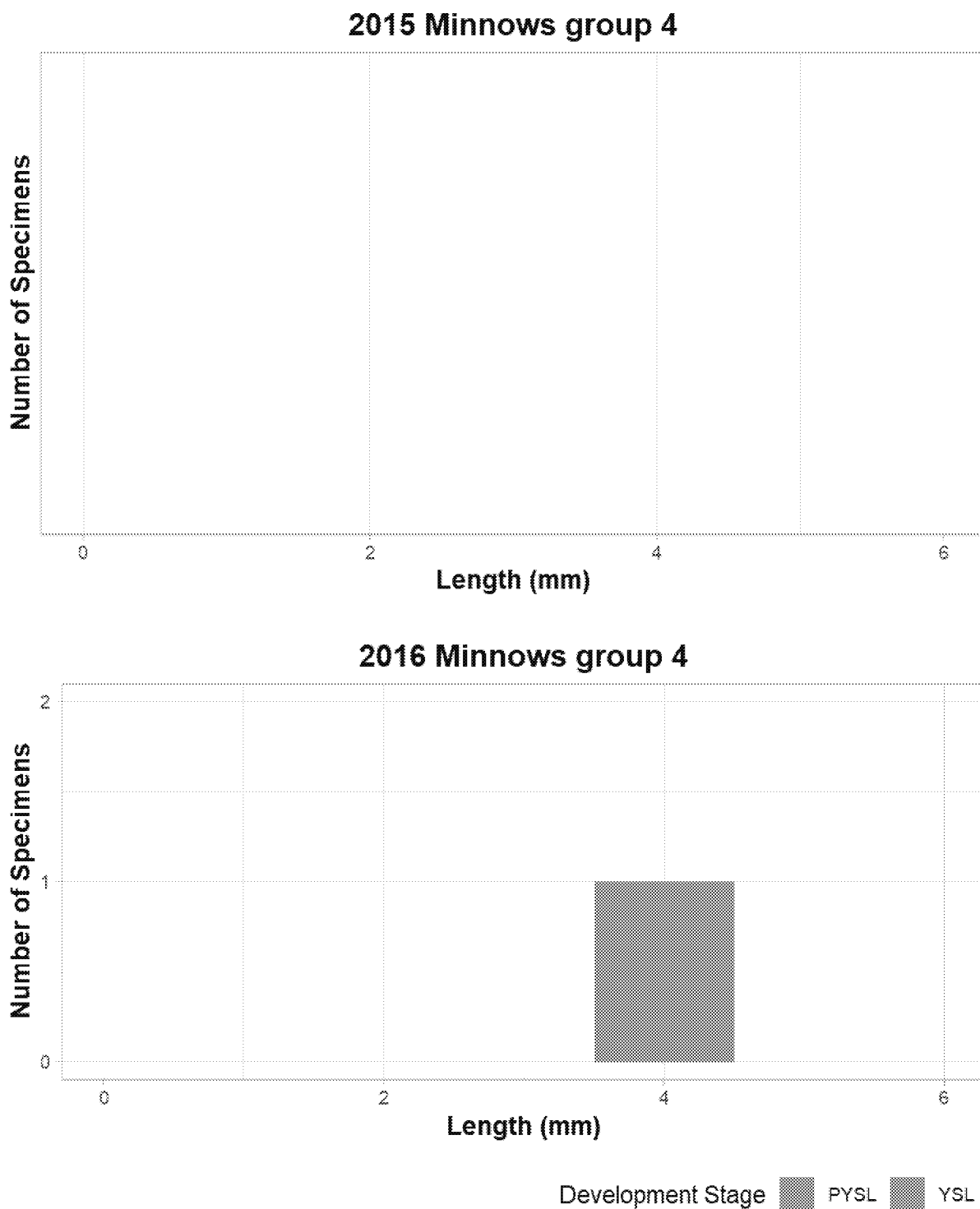
**Figure 9 D-18 Length Histogram of Entrained Minnow Family (Cyprinidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



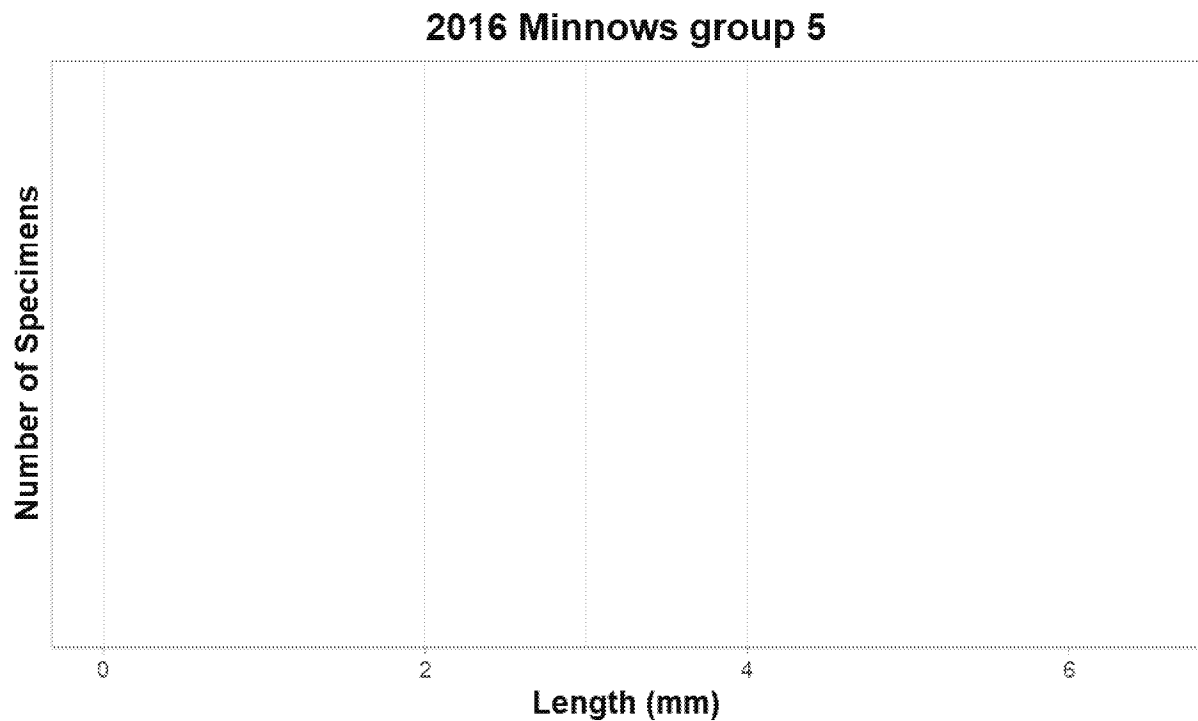
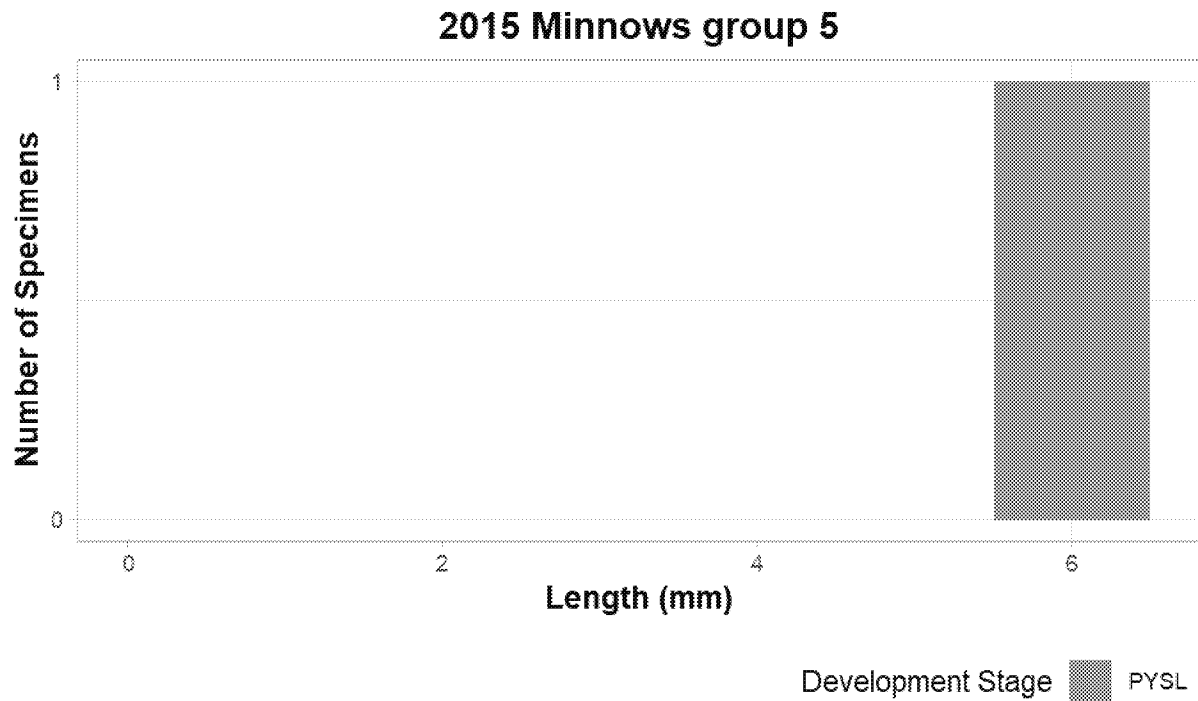
**Figure 9 D-19 Length Histogram of Entrained Minnow Group 2 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



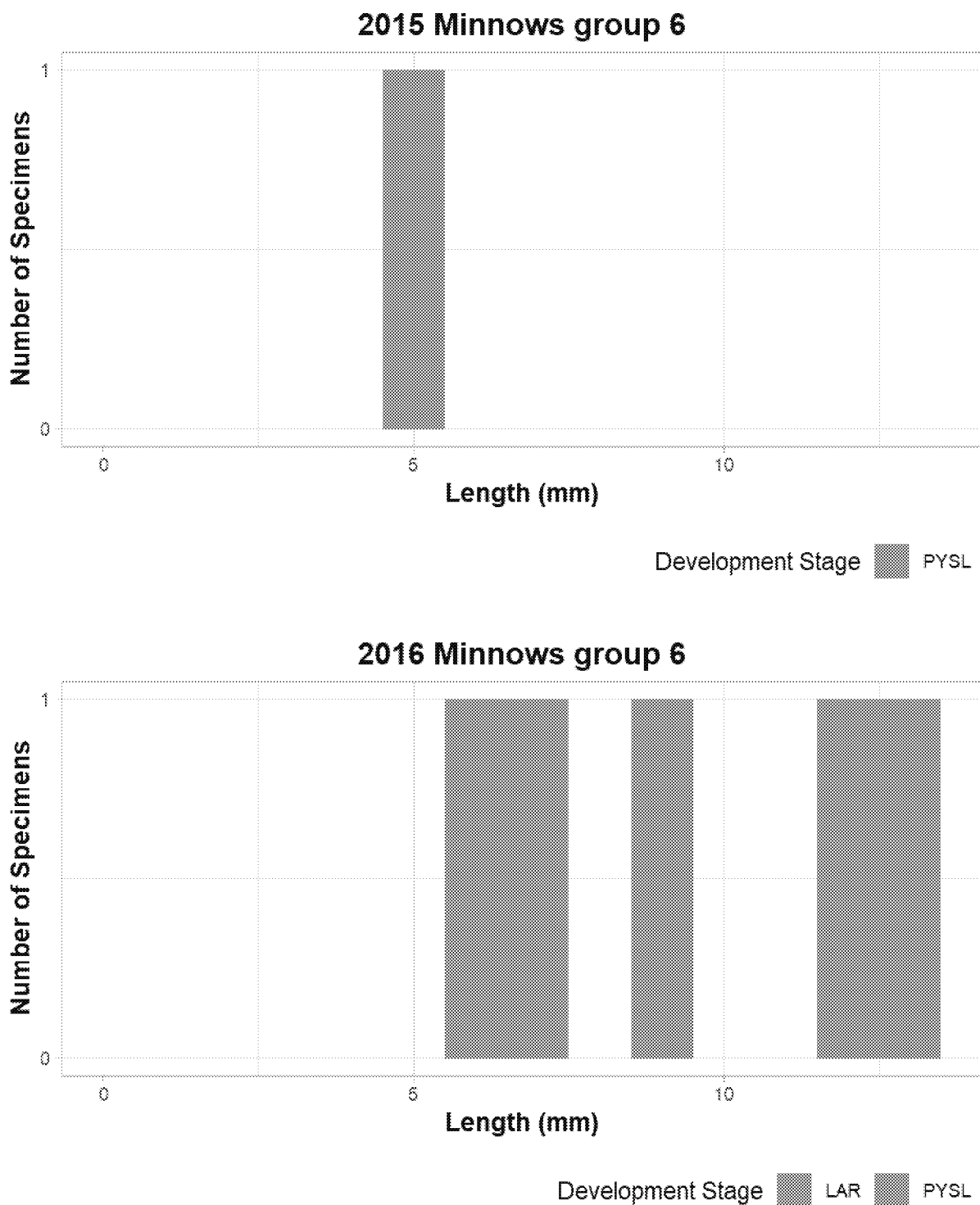
**Figure 9 D-20 Length Histogram of Entrained Minnow Group 3 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



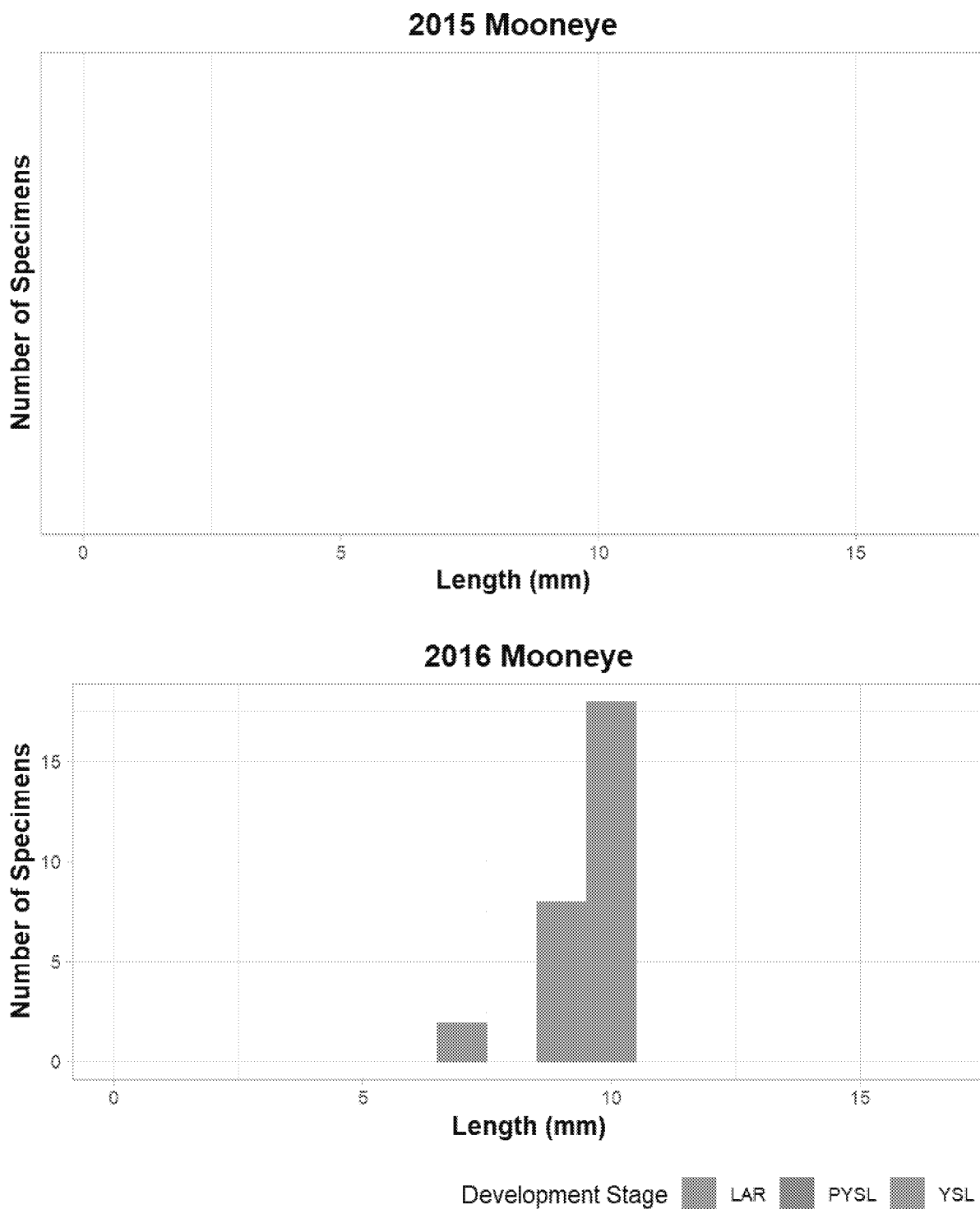
**Figure 9 D-21 Length Histogram of Entrained Minnow Group 4 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-22 Length Histogram of Entrained Minnow Group 5 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-23 Length Histogram of Entrained Minnow Group 6 Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-24 Length Histogram of Entrained Mooneye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

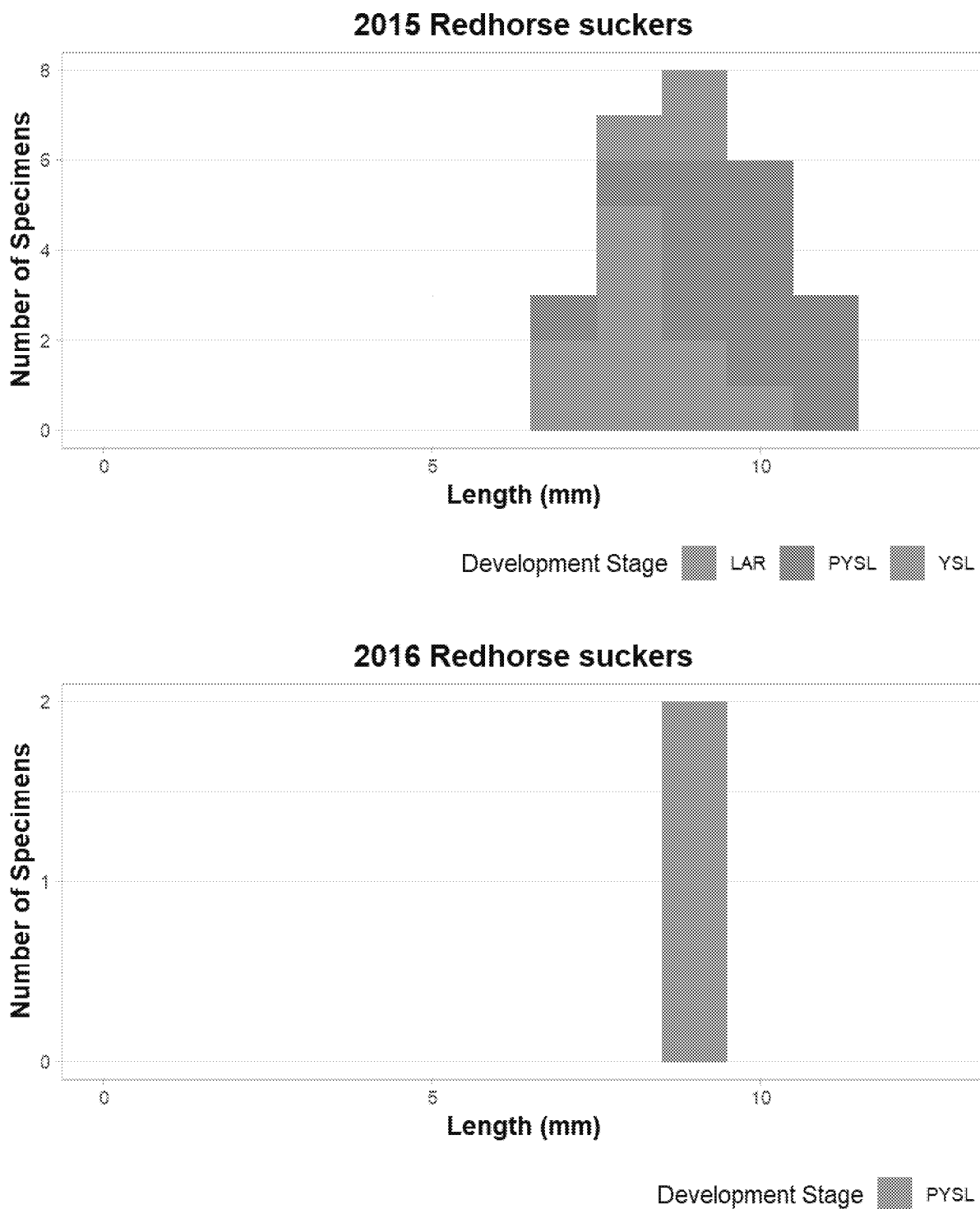
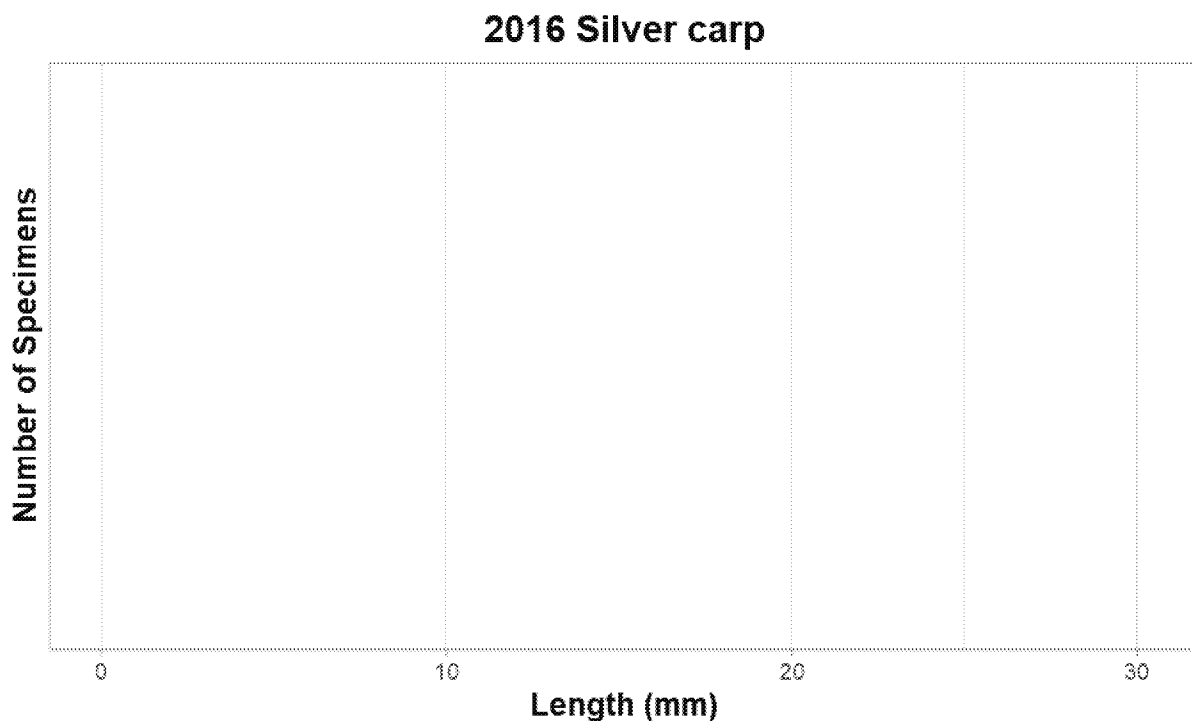
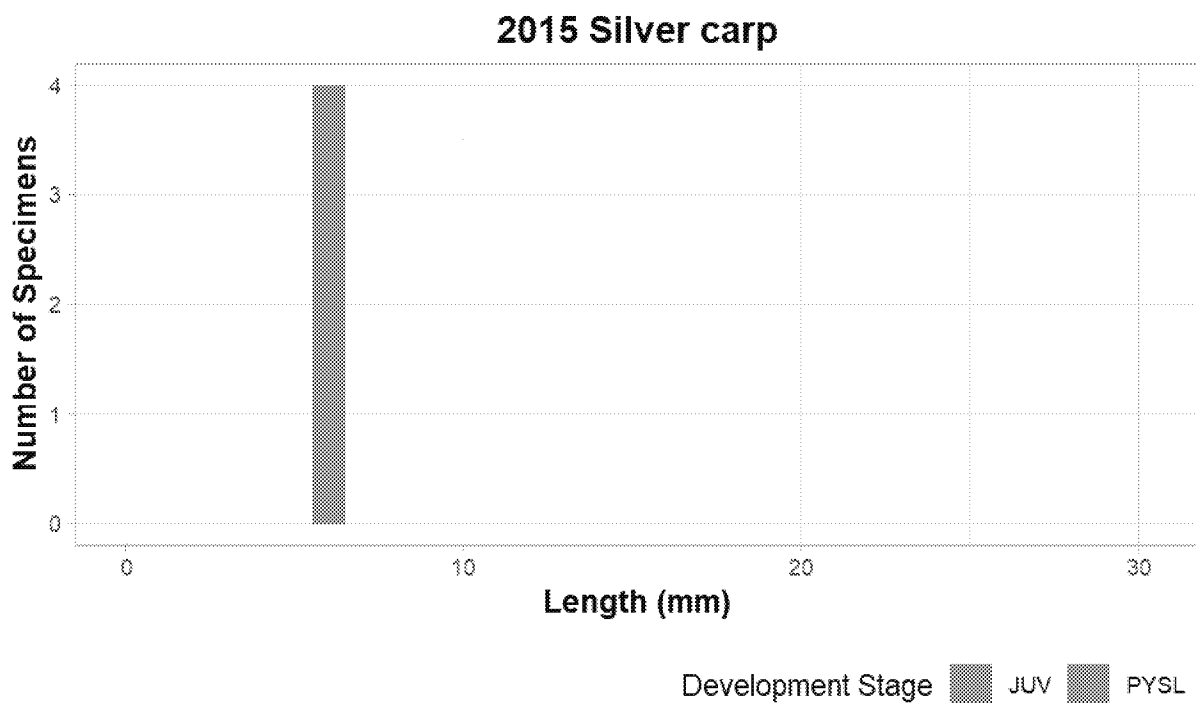
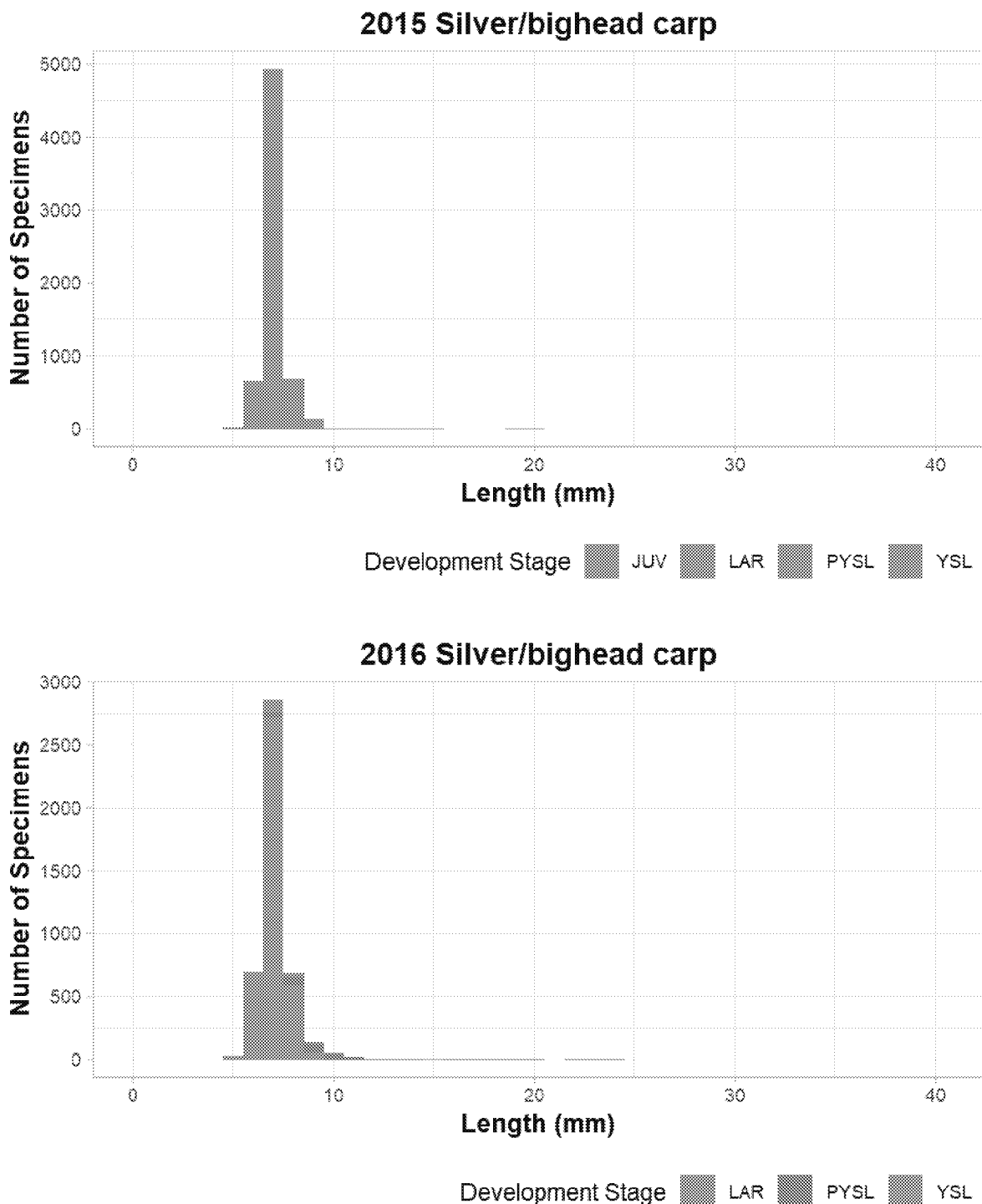


Figure 9 D-25 Length Histogram of Entrained Redhorses (*Moxostoma* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

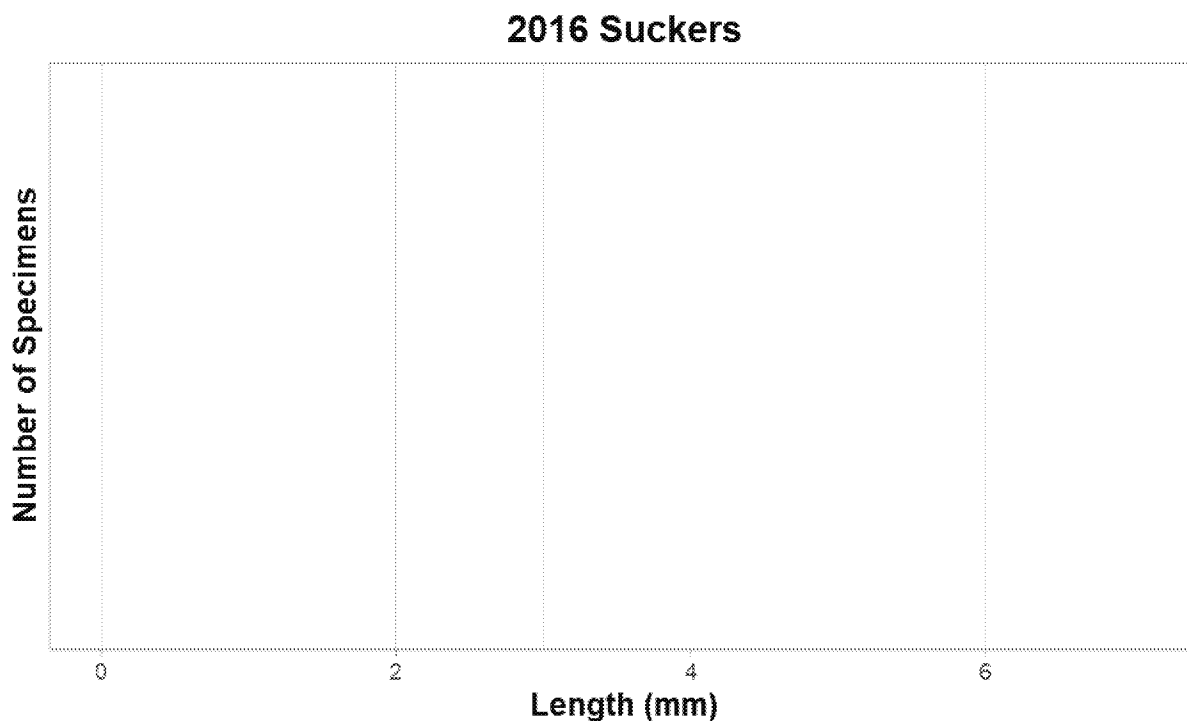
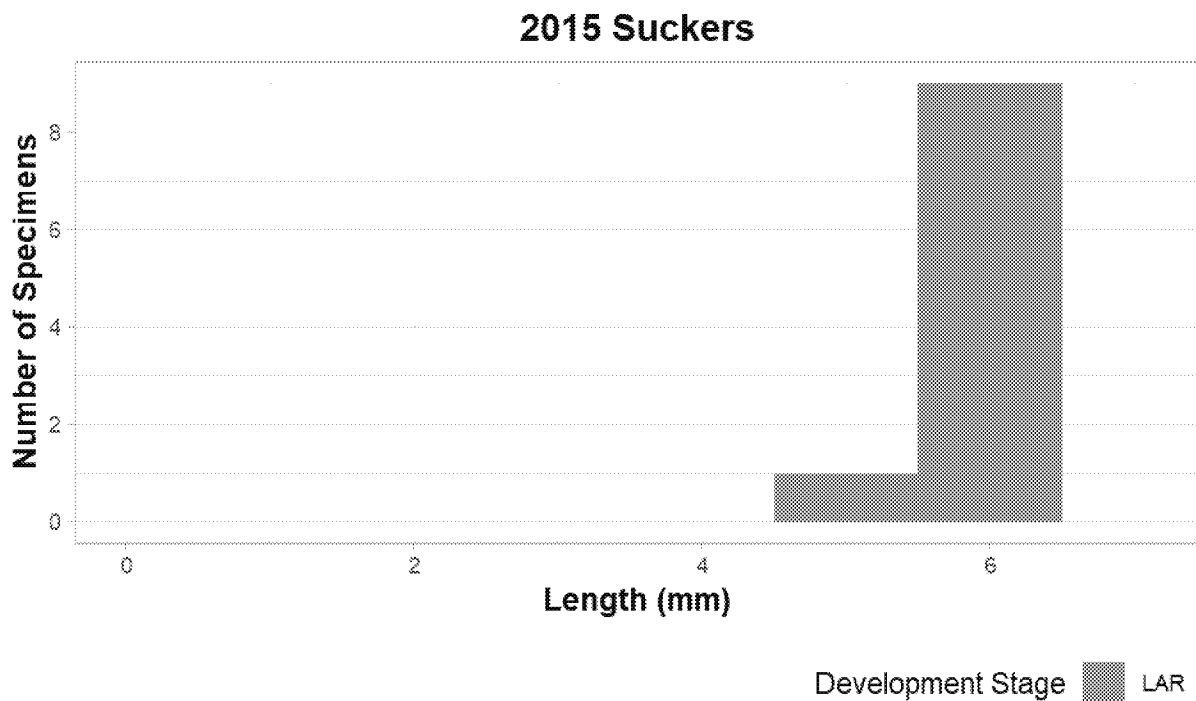




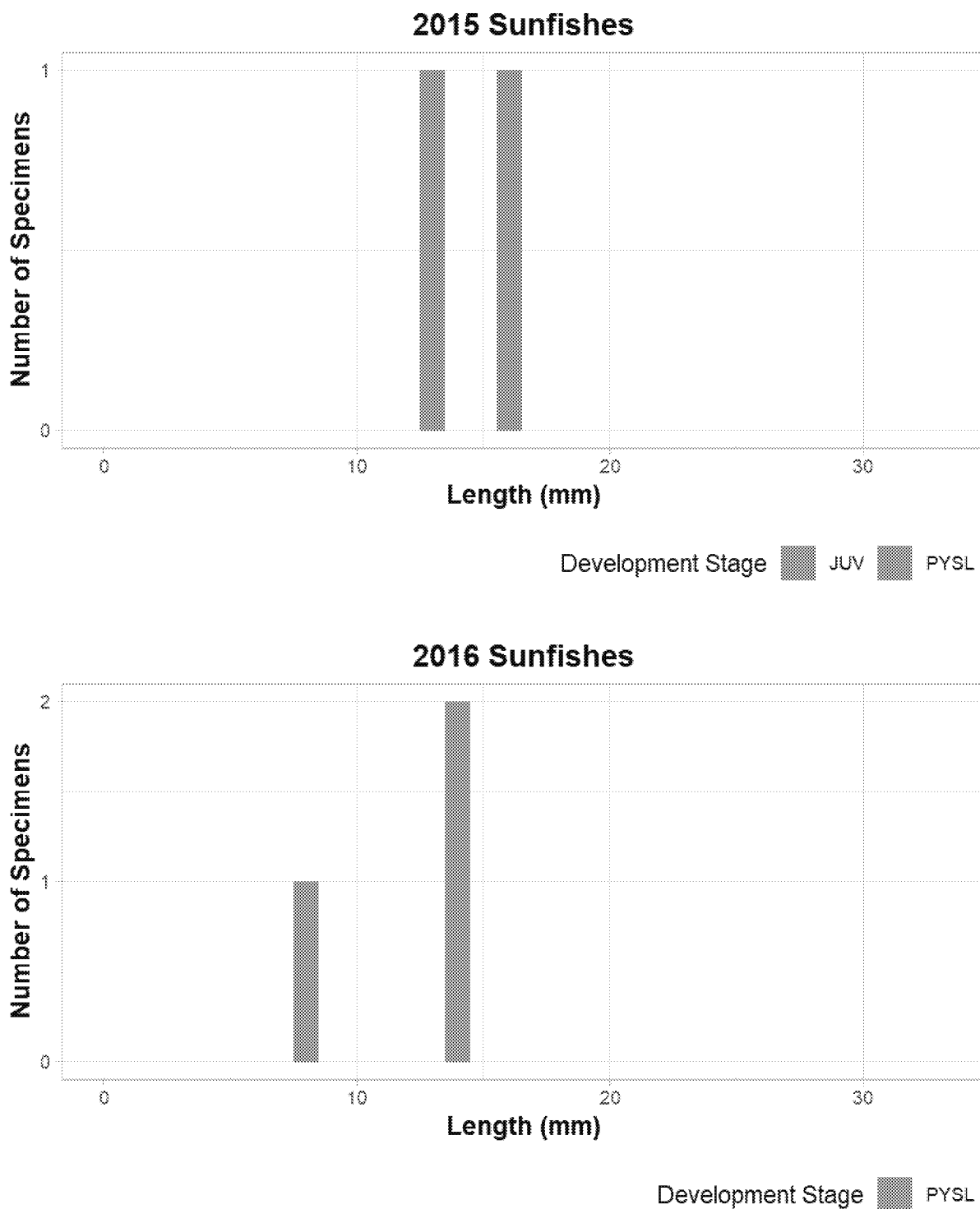
**Figure 9 D-26 Length Histogram of Entrained Silver Carp by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-27 Length Histogram of Entrained Silver Carp and Bighead Carp (*Hypophthalmichthys* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-28 Length Histogram of Entrained Sucker Family (Catostomidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**



**Figure 9 D-29 Length Histogram of Entrained Sunfish Family (Centrarchidae) Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

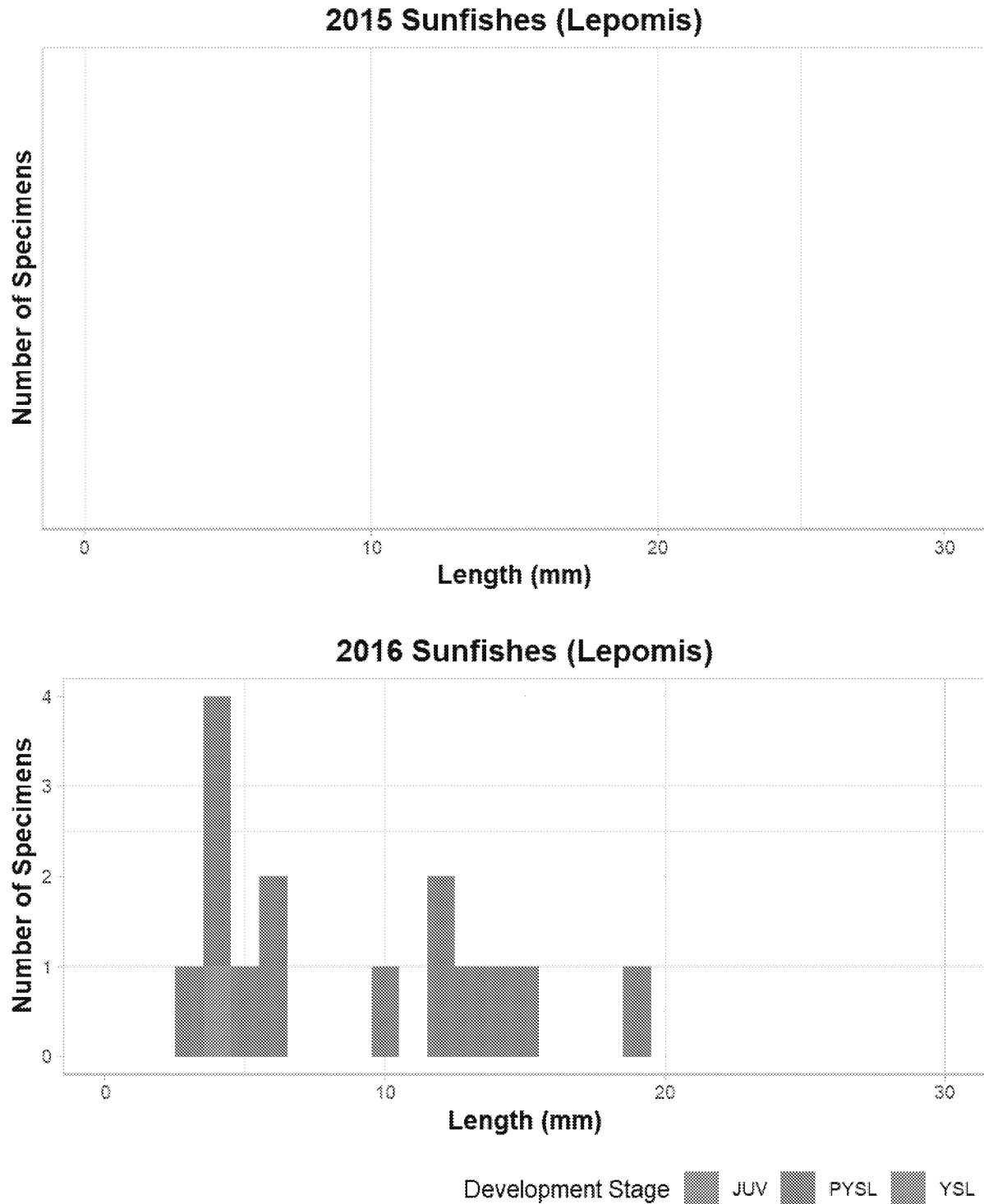


Figure 9 D-30 Length Histogram of Entrained Sunfishes (*Lepomis* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.

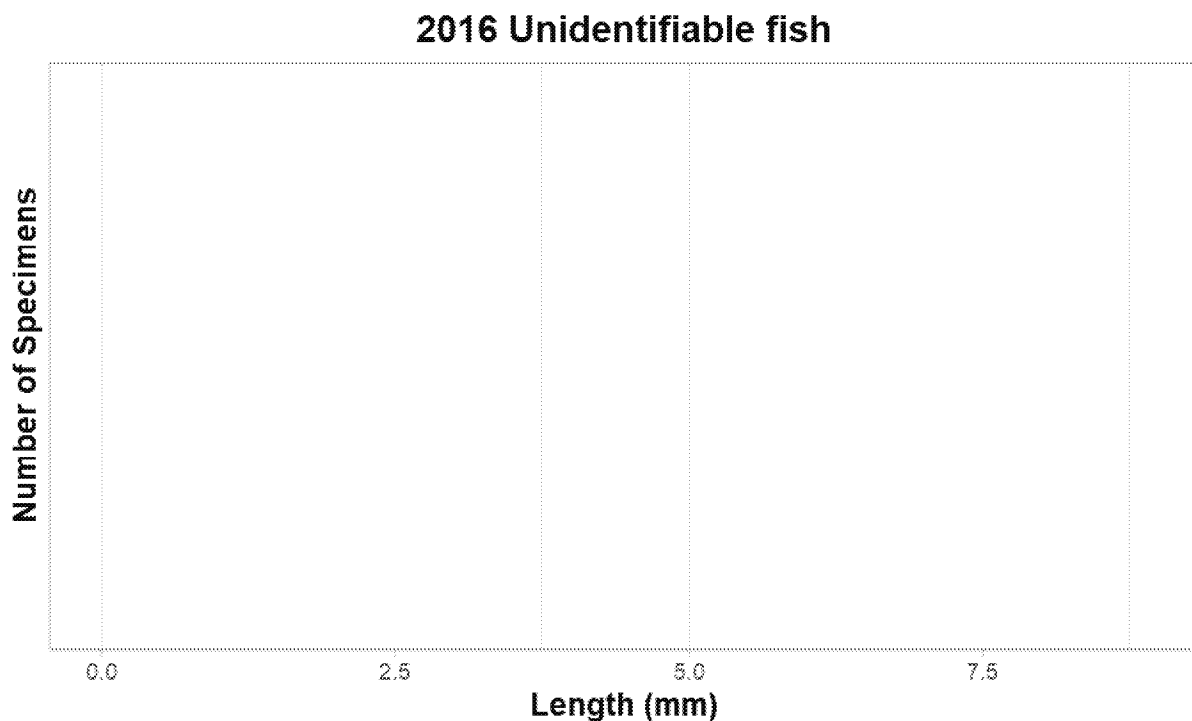
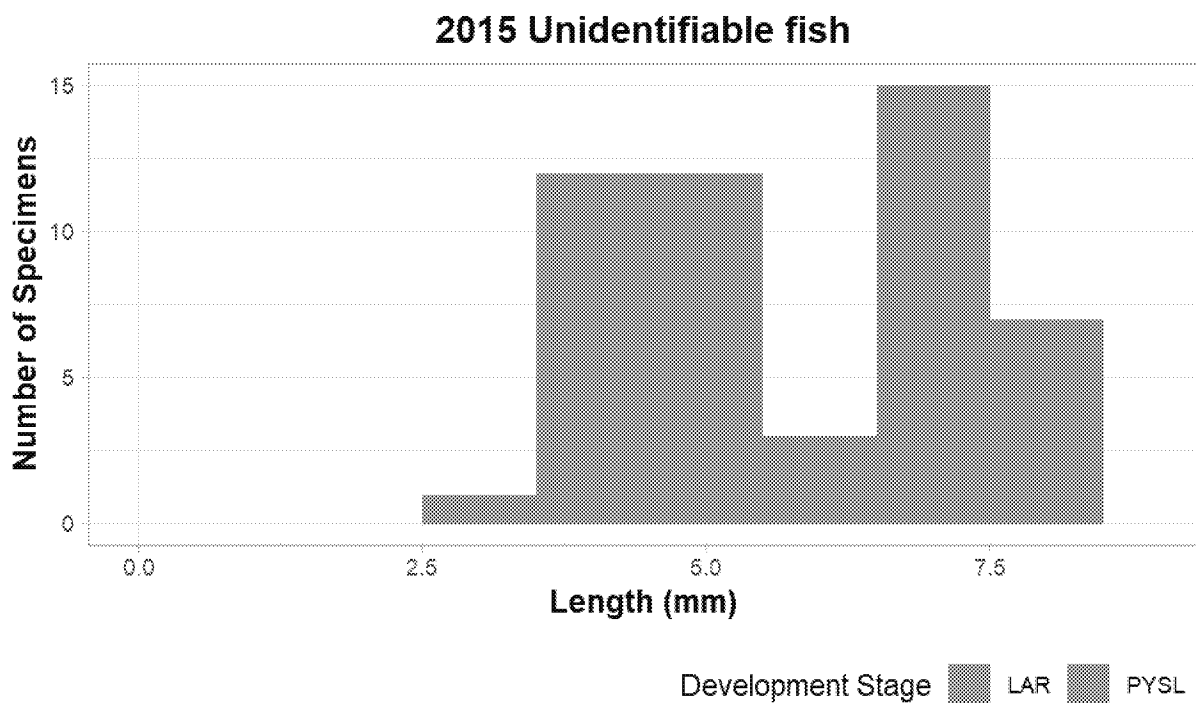
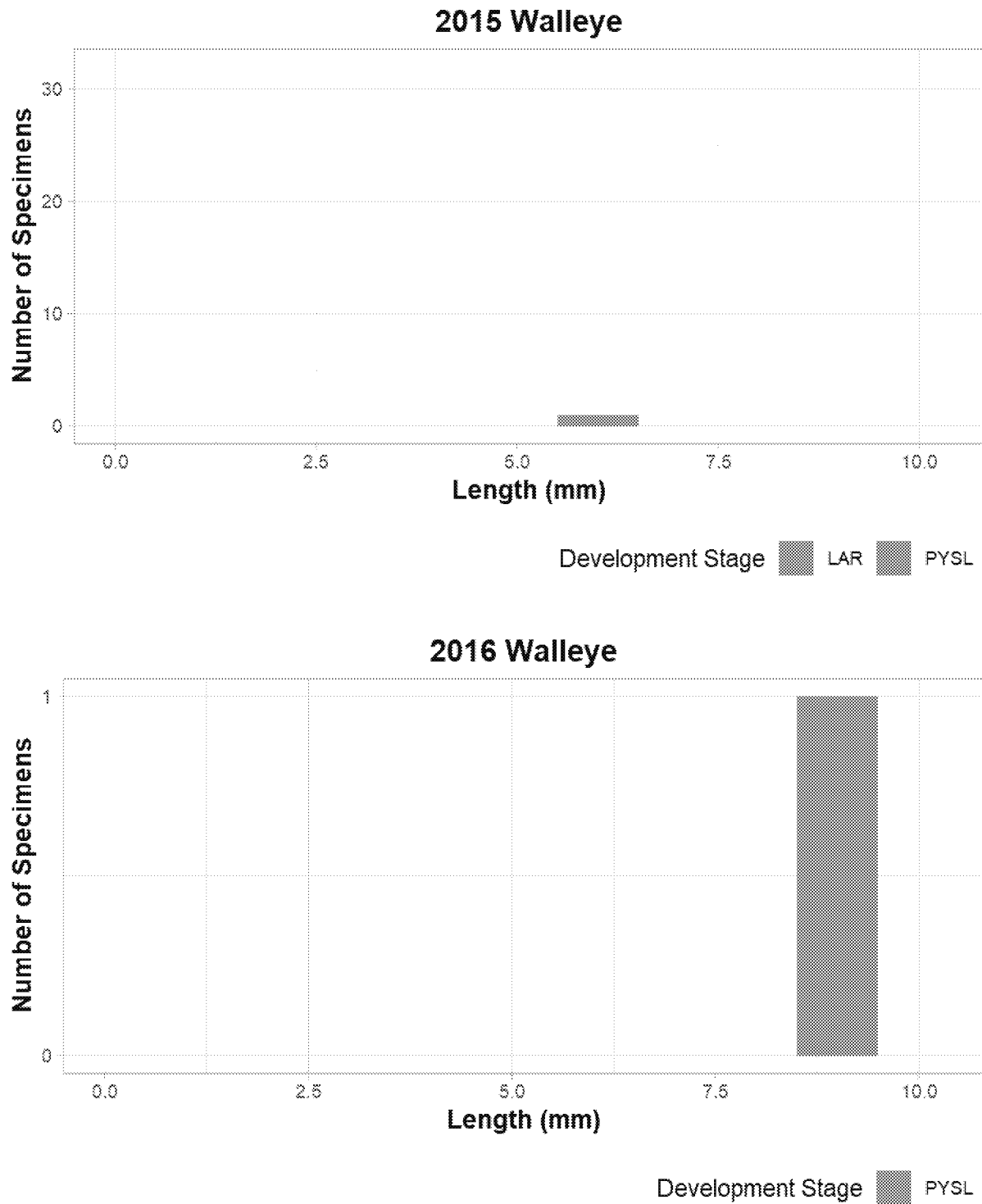


Figure 9 D-31 Length Histogram of Entrained Unidentifiable Fishes by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



**Figure 9 D-32 Length Histogram of Entrained Walleye by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

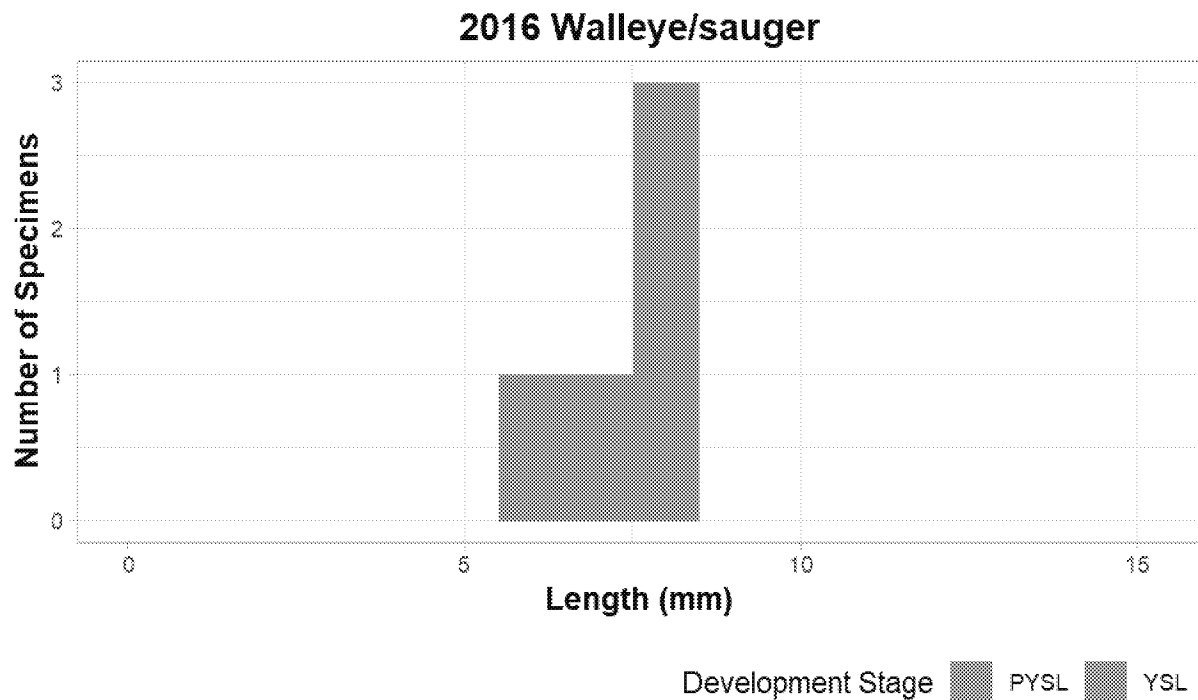
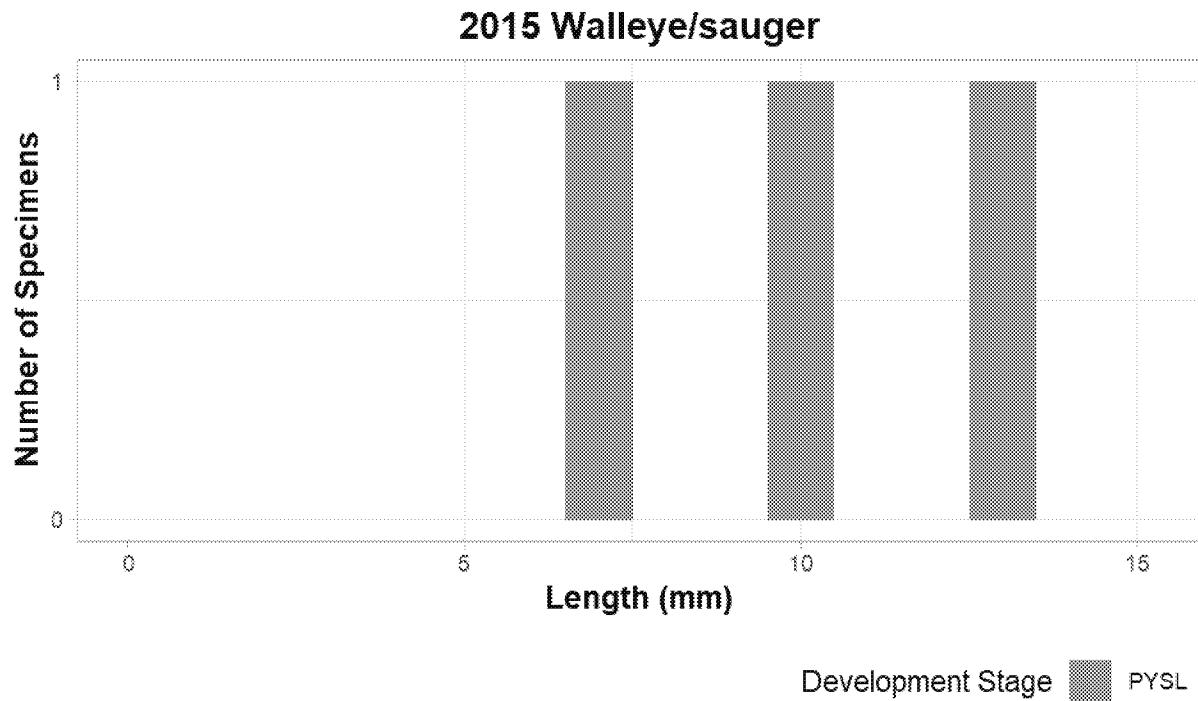


Figure 9 D-33 Length Histogram of Entrained Walleye and Sauger (*Sander* sp.) by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



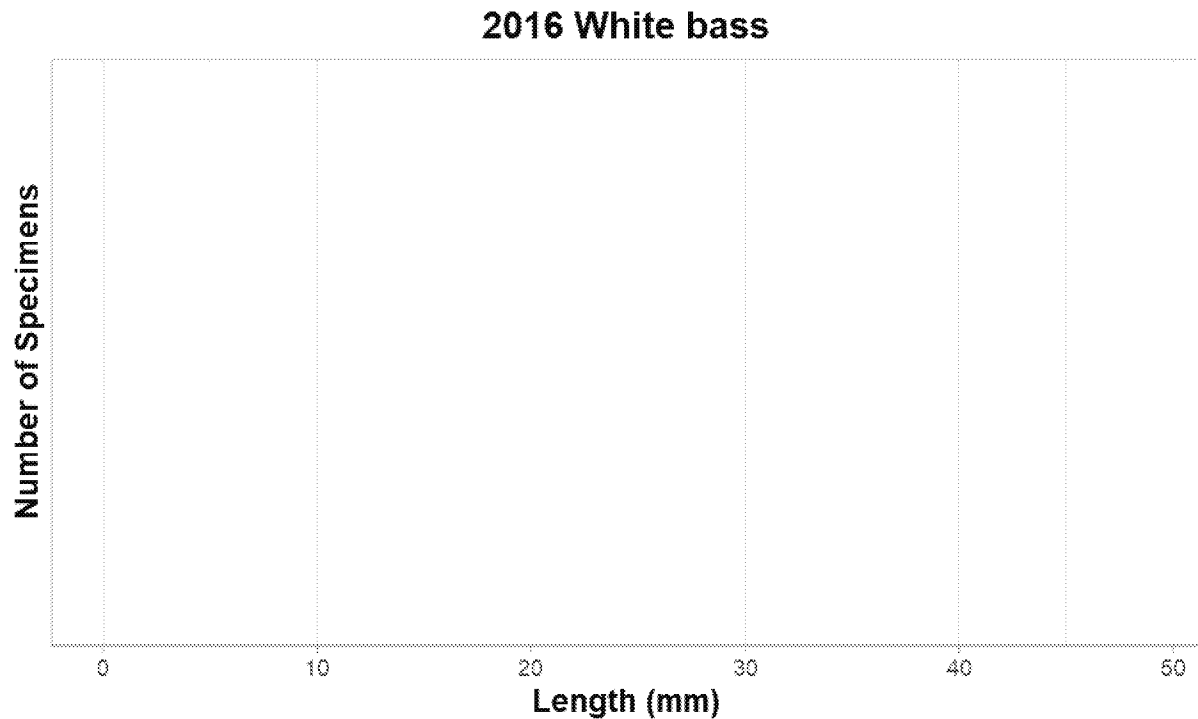
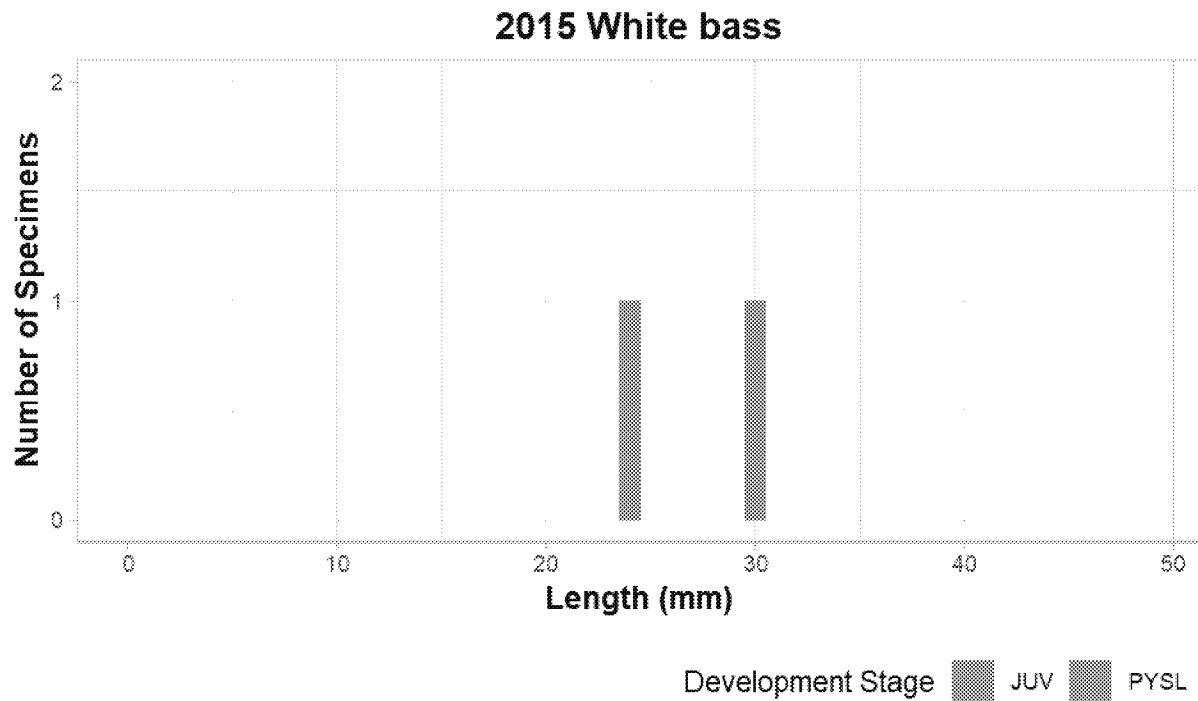
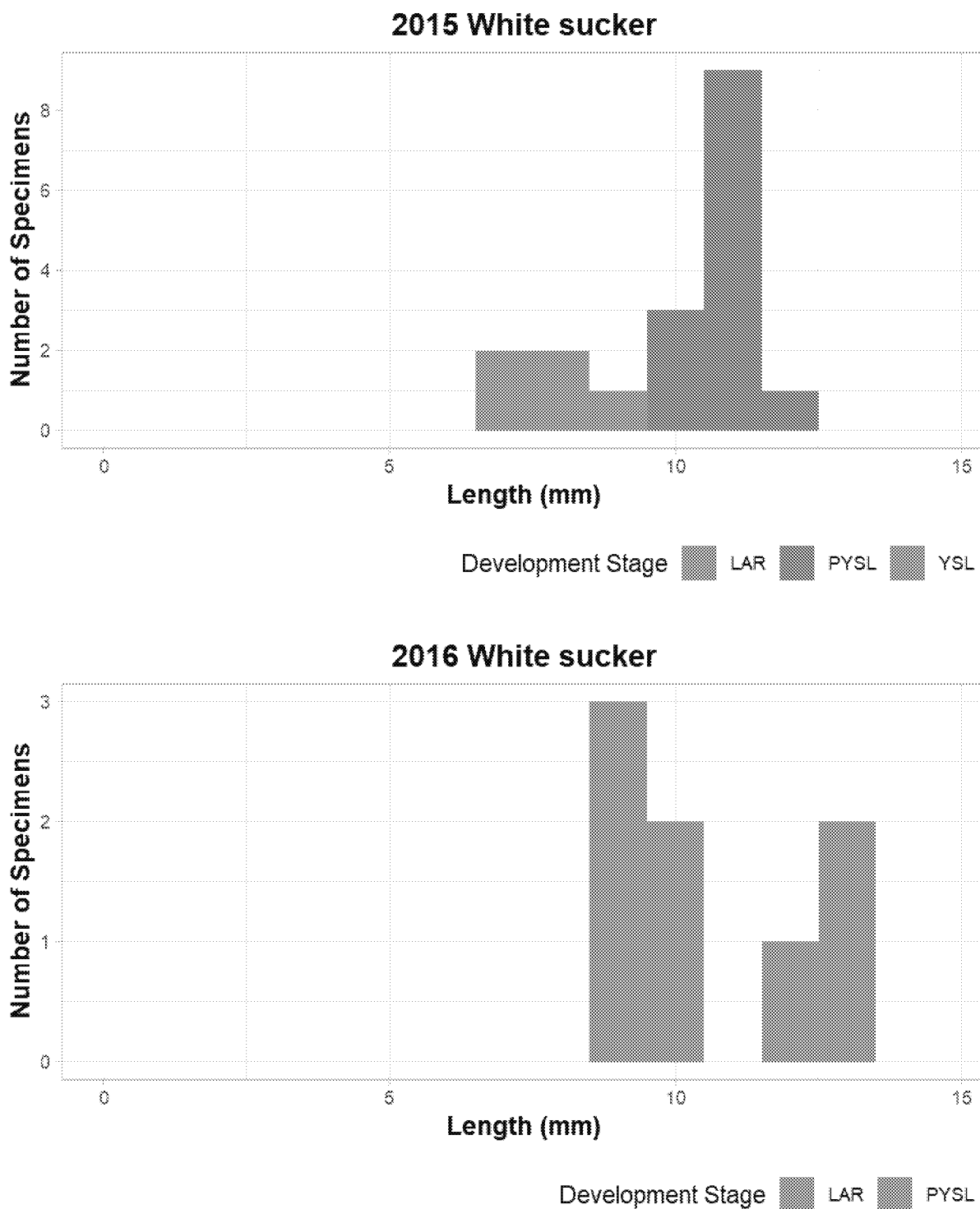


Figure 9 D-34 Length Histogram of Entrained White Bass by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.



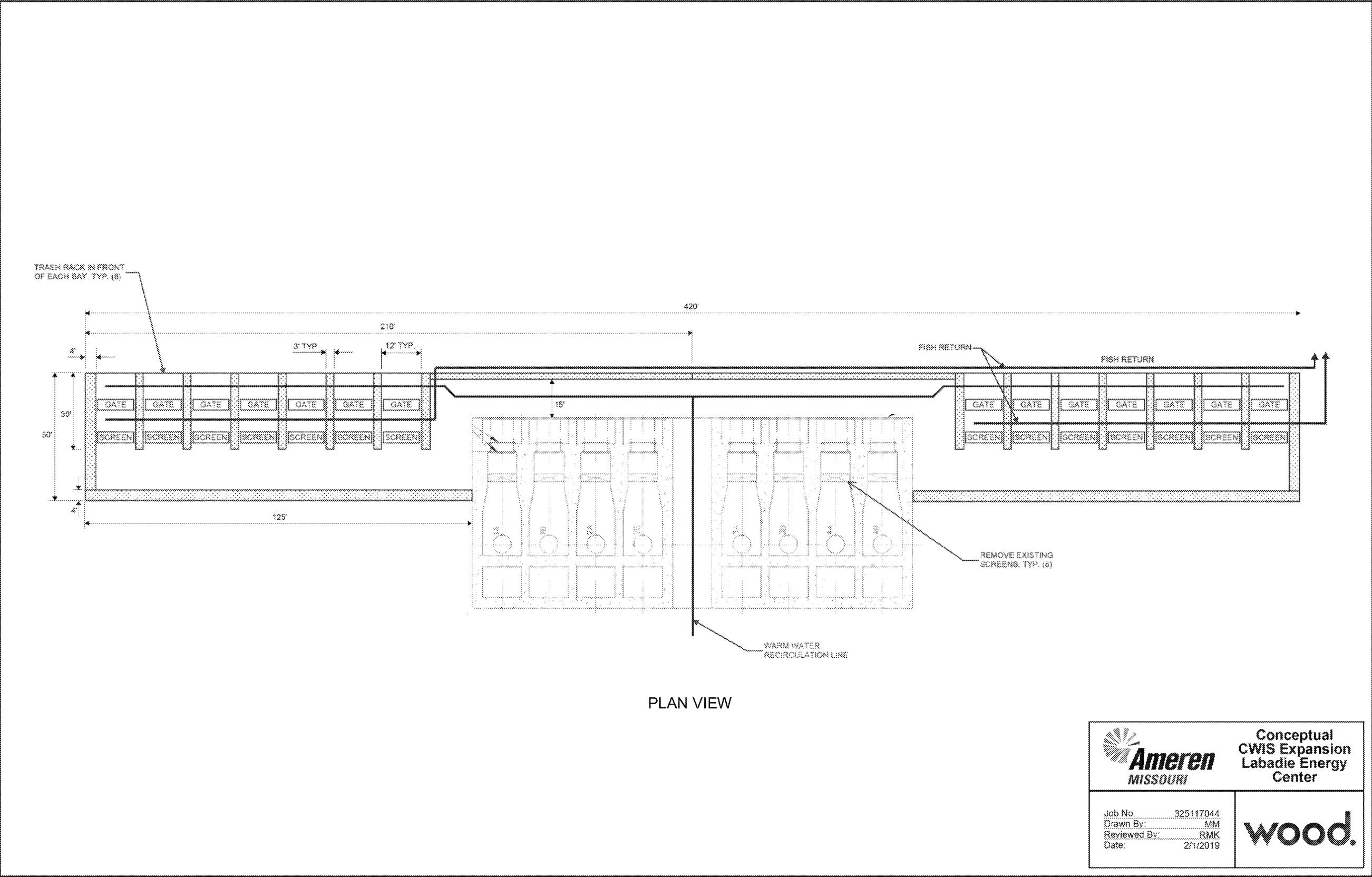
**Figure 9 D-35 Length Histogram of Entrained White Sucker by Development Stages Collected During 2015 and 2016 Sampling Conducted at the LEC.**

## **Appendix 10 A**

### **40 CFR 122.21(r)(10) – Technical Feasibility and Cost Evaluation**

#### **Conceptual Cooling Water Intake Structure Expansion**

Appendix 10 A. Conceptual CWIS Expansion



Appendix 10 B. Burns and McDonnell - Ameren Labadie Energy Center Thermal Discharge Best Available Technology Economically Achievable Analysis